

# FINAL REPORT

Enhanced Oxidative Bioremediation of cis-dichloroethene (cis-DCE)  
and Vinyl Chloride (VC) using Electron Shuttles

ESTCP Project ER-0316

JULY 2009

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<b>Report Documentation Page</b>			<i>Form Approved OMB No. 0704-0188</i>	
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1. REPORT DATE <b>JUL 2009</b>	2. REPORT TYPE	3. DATES COVERED <b>00-00-2009 to 00-00-2009</b>		
4. TITLE AND SUBTITLE <b>Enhanced Oxidative Bioremediation of cis-dichloroethene (cis-DCE) and Vinyl Chloride (VC) using Electron Shuttles</b>		5a. CONTRACT NUMBER		
		5b. GRANT NUMBER		
		5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S)		5d. PROJECT NUMBER		
		5e. TASK NUMBER		
		5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Naval Facilities Engineering and Expeditionary Warfare Center,1000 23rd Avenue,Port Hueneme,CA,93043</b>		8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)		
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)		
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>				
13. SUPPLEMENTARY NOTES				
14. ABSTRACT				
15. SUBJECT TERMS				
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Same as Report (SAR)</b>	18. NUMBER OF PAGES <b>219</b>
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>	19a. NAME OF RESPONSIBLE PERSON	

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# Acronyms and Abbreviations

AFB	Air Force base
AFCEE	Air Force Center for Engineering and the Environment
AQDS	Anthraquinone disulfonic acid
AQS	2-Anthraquinone sulfonic acid
BAFeIII	Bioavailable ferric iron
CDM	Camp Dresser & McKee Inc.
<i>cis</i> -DCE	<i>cis</i> -1,2-Dichloroethene
COCs	Contaminants of concern
DO	Dissolved oxygen
EPA	Environmental Protection Agency
ESTCP	Environmental Security Technology Certification Program
FA	Fulvic acid
Fe <sup>+2</sup>	Ferrous iron
Fe <sup>+3</sup>	Ferric iron
FeRB	Iron-reducing bacteria
ft bgs	Feet below ground surface
g/L	Grams per liter
GC/RD	Gas chromatography with radiometric detection
HA	Humic acid
IHSS	International Humic Substances Society
IR	Installation Restoration
K <sub>OC</sub>	Organic carbon partition coefficient
L/kg	Liters per kilogram
LF-3	Landfill 3
mg	Milligrams
mg/L	Milligrams per liter
mg-N/L	Milligrams nitrogen per liter
mL/min	Milliliters per minute
mM	Millimoles per liter
MSL	Mean sea level
MTBE	Methyl tertiary butyl ether
mV	Millivolts
NA	Not available or not applicable
NAVFAC	Naval Facilities Engineering Command
NFESC	Naval Facilities Engineering Service Center
ORP	Oxidation-reduction potential
PCE	Tetrachloroethene
SSC-OTC	Space and Naval Warfare Systems Center Old Town Campus

TCE	Trichloroethene
TOC	Total organic carbon
µg/L	Micrograms per liter
µmole	Micromole
USCS	Unified Soil Classification System
USGS	United States Geological Survey
VC	Vinyl chloride
VOCs	Volatile organic compounds
WHO	World Health Organization

# Section 1

## Introduction

### 1.1 Project Scope

The original scope of this project involved demonstration and validation of the use of electron shuttles compounds for the oxidative biodegradation of *cis*-1,2-dichloroethene (*cis*-DCE) and vinyl chloride (VC). As results from the treatability study using radiolabeled vinyl chloride were not encouraging, the project was cancelled. Since this project was not completed as planned, this final report does not follow the standard Environmental Security Technology Certification Program (ESTCP) report format. This report presents the findings from field sampling and analysis and treatability testing that was conducted at both Dr. Derek Lovley's and Dr. Frank Chapelle's laboratories. Specifically, this report includes the following:

- A brief description of electron shuttling processes and example electron shuttle properties.
- The revised objectives of this study and a diagram indicating the interrelationships amongst the different aspects.
- Materials and methods used in the study along with brief descriptions of the sites where samples were collected.
- Results of the study including: 1) electron shuttle characterization (work performed at Dr. Derek Lovley's laboratory), 2) site sampling and analysis; and 3) microcosm testing (work performed at Dr. Frank Chapelle's laboratory).
- Conclusions of the study.

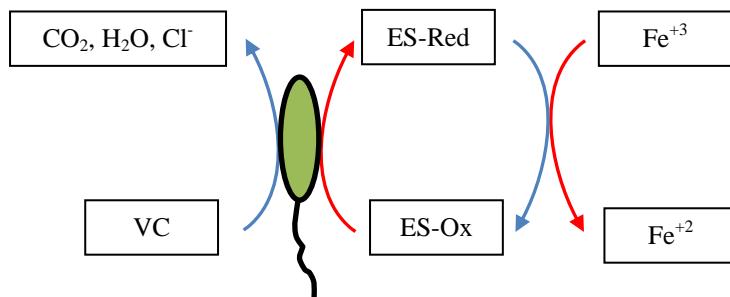
Upon cancellation of ER0316, obligated ESTCP funds were redirected towards two related and parallel efforts. The first effort was a Workshop on *In Situ* Biogeochemical Transformation. A separate report on the findings of this workshop was previously delivered and has been published (AFCEE, 2008). The second effort involved sampling and analysis of Air Force biowall sites where biogeochemical transformation appears to have been occurring. This work is in progress and a report is in preparation.

### 1.2 Electron Shuttle Background

Electron shuttles are compounds that stimulate biodegradation of contaminants by facilitating electron transfer to and from bacteria (Benz et al. 1998, Bradley et al. 1998, Finneran and Lovley 2001, Hernandez and Newman 2001, Lovley et al. 1996a, Lovley et al. 1998, Newman and Kolter 2000, Scott et al. 1998). These compounds can accept electrons from bacteria that are oxidizing a contaminant such as VC (Bradley et al. 1998) and subsequently donate those electrons to a terminal electron acceptor such as ferric iron. Electron shuttles can facilitate oxidative and potentially reductive modes of contaminant biodegradation.

In the oxidative role, an electron shuttle serves as the initial electron acceptor. Bacteria donate electrons to the electron shuttle following oxidation of the contaminant. If another terminal electron acceptor such as ferric iron ( $\text{Fe}^{+3}$ ) is present, the reduced electron shuttle donates electrons to ferric iron and in doing so is regenerated (i.e., oxidized) and ferrous iron ( $\text{Fe}^{+2}$ ) is produced. The regenerated electron shuttle is then capable of facilitating additional contaminant oxidation.

**Figure 1** is a schematic representation of the electron shuttling process using VC as an example contaminant. This shuttling of electrons between bacteria and ferric iron highlights the utility of electron shuttles. Ferric iron is present as a solid phase in aquifers and is not always in intimate contact with bacteria. The electron shuttle functions as an electronic bridge between the bacteria and the ferric iron and in doing so maximizes the bioavailability of this ubiquitous terminal electron acceptor.



**Figure 1 Example Electron Shutting Schematic Diagram Showing Cycling of Reduced (ES-Red) and Oxidized (ES-Ox) Electron Shuttles.**

One reason that the availability of electron shuttles has a significant impact on contaminant oxidation is that iron-reducing bacteria (FeRB) are capable of degrading organic contaminants including VC, *cis*-DCE, benzene, toluene, and methyl tertiary butyl ether (MTBE) (Anderson et al. 1998, Bradley and Chapelle 1996, Bradley and Chapelle 1998, Finneran and Lovley 2001, Lovley et al. 1996b, Lovley 1997). The ability of FeRB to degrade these contaminants *in situ* is often limited by bioavailability of ferric iron. Electron shuttles such as humic acids and anthraquinone disulfonic acid (AQDS) have been shown to enhance biodegradation of organic chemicals including VC and *cis*-DCE (Bradley et al. 1998), benzene (Lovley et al. 1996a,b), toluene (Evans 2000), and MTBE (Finneran and Lovley 2001). Column studies have demonstrated that electron shuttles stimulated toluene biodegradation under iron-reducing conditions (Evans 2000).

Enhancement of bioremediation using electron shuttles is a potentially feasible and cost-effective approach to site remediation. This technology could be applied at chlorinated solvent sites where the accumulation of *cis*-DCE and VC has been observed. For example, electron shuttles have been observed to increase the biodegradation rates of *cis*-DCE and VC in microcosms (Bradley et al. 1998). *cis*-DCE and VC are of particular interest since they are ubiquitously found at sites where complete reductive dechlorination of tetrachloroethene (PCE) or trichloroethene (TCE) was incomplete. This is often the situation at natural attenuation sites as well as many sites where enhanced anaerobic bioremediation has been attempted.

In a typical remediation scenario, the selected electron shuttle formulation would be added to groundwater through a series of injection wells or in a trench. Ideally, the electron shuttle formulation would be transported downgradient along the natural groundwater flow path. Groundwater can be recirculated if regulatory requirements require capture of the injected electron shuttles or if increased residence times are desired. If downgradient groundwater needs to be extracted it can be reintroduced through the injection trench or wells. Additional electron shuttles could be added to the extracted groundwater as necessary. As the electron shuttles are transported downgradient, they will accept electrons from bacteria that have oxidized VC and *cis*-DCE. The reduced electron shuttles will then donate the electrons to bioavailable ferric iron or other terminal electron acceptors. The regenerated electron shuttles will continue to shuttle electrons between the bacteria and the terminal electron acceptors until they are transported beyond the plume boundary or capture zone.

Examples of electron shuttles include humic and fulvic acids, quinones such as the humic acid analogue AQDS, phenazines, and potentially thiol-containing molecules such as cysteine (Hernandez and Newman 2001; Lovley et al. 1998). The chemical structures of these compounds typically include aromatic resonance structures as shown in **Figure 2**. Humic and fulvic acids are naturally abundant in nature. AQDS is a synthetic compound that is unlikely to be used in the field because of regulatory restrictions on its injection. Alternative compounds such as the food colorant indigo disulfonic acid are potential alternatives that were evaluated in this study. In general, factors that affect practical applications include electron shuttling efficiency, fate and transport in the environment, toxicity, solubility, and cost. **Table 1** lists various electron shuttle candidates and gives an overview of their chemical and toxicological properties. Additional information on the toxicology of humic acids, AQDS, and indigo disulfonate is presented in Appendix A.

#### Example Electron Shutlasses and Structures

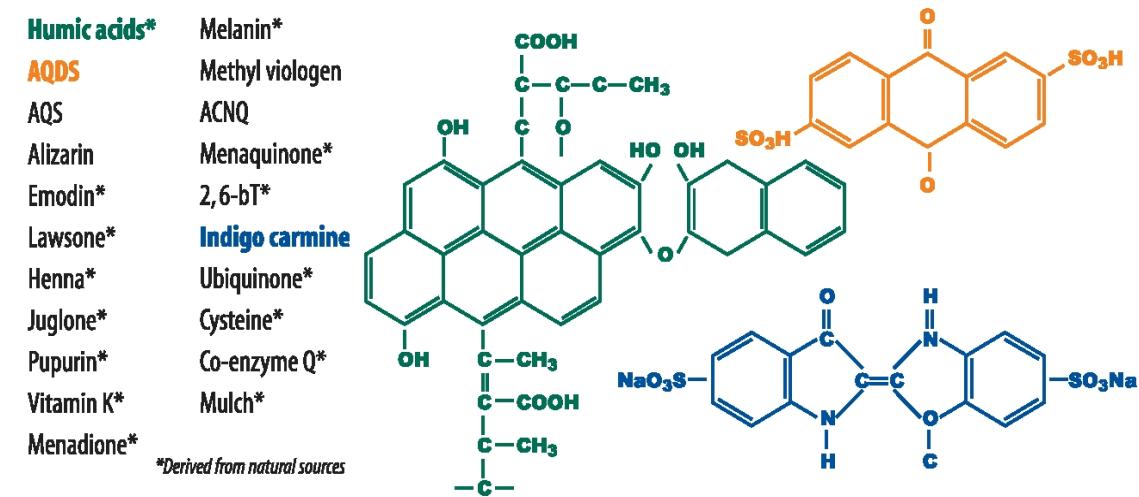


Figure 2 Electron Shuttle Chemical Structures

**Table 1**  
Electron Shuttle Chemistry and Toxicity

Common Name(s)	Chemical Name	CAS No.	Formula	Molecular Weight	Health Hazards Acute and Chronic	LD50 for Mouse/Rat (mg/kg)	Solubility in Water	Standard Potential, E° (V)	References
ACNQ	2-Amino-3-carboxy-1,4-naphthoquinone	NA	C <sub>11</sub> H <sub>7</sub> NO <sub>4</sub>	217	NA	NA	NA	-0.071	1, 2, 14
Alizarin, Pigment Red	1,2-dihydroxyanthraquinone	72-48-0	C <sub>14</sub> H <sub>8</sub> O <sub>4</sub>	240.21	Acute: causes irritation to the respiratory tract, symptoms may include coughing, shortness of breath, causes irritation to skin, symptoms include redness, itching, and pain, may cause dermatitis, causes irritation, redness, and pain of the eyes. Chronic: No information found. Based on animal studies, substance is presumed to be moderately toxic.	NA	2.5 µM	--	13
Anthraquinone-2-sulfonic Acid Sodium Salt; Sodium Anthraquinone-beta-sulfonate; AQS	Anthraquinone-2-sulfonic acid	131-08-8	C <sub>14</sub> H <sub>7</sub> O <sub>5</sub> Na	310.26	Acute: may cause eye irritation, skin irritation, irritation of the digestive tract, respiratory tract irritation. Chronic: No information found. The toxicological properties of this substance have not been fully investigated.	663 (630 to 730)	Freely Soluble	-0.23	9
AQDS, 26AQDS; Anthraquinone-2,6-Disulfonate	Anthraquinone-2,6-disulfonic acid	853-60-9	C <sub>14</sub> H <sub>6</sub> O <sub>8</sub> S <sub>2</sub> Na <sub>2</sub>	412.29	Acute: may cause eye irritation, skin irritation, irritation of the digestive tract, respiratory tract irritation. Chronic: No information found. The toxicological properties of this substance have not been fully investigated.	2900	Soluble	-0.18	2, 3, 15, 16
Coenzyme Q	2,3-Dimethoxy-5-methyl-1,4-benzoquinone	605-94-7	C <sub>9</sub> H <sub>10</sub> O <sub>4</sub>	182.17	NA		11.1g/L	0.174	15
Cysteine	Cysteine	3374-22-9	C <sub>3</sub> H <sub>7</sub> NO <sub>2</sub> S	121.16	Acute: No adverse health effects expected from inhalation, ingestion (large oral doses may cause general depressed activity), skin exposure. Chronic Exposure: No adverse health effects expected.	NA	Freely soluble	-0.39	18
Emodin	6-Methyl-1,3,8-trihydroxyanthraquinone	518-82-1	C <sub>15</sub> H <sub>10</sub> O <sub>5</sub>	270.23	Acute: causes eye irritation, skin irritation, respiratory tract irritation, may cause irritation of the digestive tract. Chronic: No information found.	NA	Insoluble	--	20
Fulvic acid, Sodium Fulvate; Fulvic acid, sodium salt	Fulvic acid	NA	NA	NA	Acute: may be harmful if swallowed. Chronic: none reported. RTC CLASS OF COMPOUND- Drug; Natural Product	1093 (1009 to 1176)	Freely soluble	--	11
Henna	Powdered Natural Henna	NA	NA	NA	Been used by humans for centuries for hair and body treatment.	NA	Paste - some components may be soluble	--	13
HGA-Melanin (polymerized homogentisic acid), Homogentisic Acid	2,5-Dihydroxyphenylacetic acid (polymerized)	451-13-8	C <sub>8</sub> H <sub>8</sub> O <sub>4</sub>	168.15	Acute: may cause eye irritation, skin irritation, irritation of the digestive tract, respiratory tract irritation. Chronic: No information found. The toxicological properties of this substance have not been fully investigated.	NA	Freely soluble	--	21
Humic acid, Huminsaure natrium; Sodium Humate;	Humic acid	68131-04-4	NA	NA	Acute: causes eye irritation, causes skin irritation, may cause irritation of the digestive tract, causes respiratory tract irritation. Chronic: No information found. The toxicological properties of this substance have not been fully investigated. RTC CLASS OF COMPOUND- Reproductive Effector.	596 (111 to 1176)	Freely soluble at pH>2	--	10
Indigodisulfonate Dipotassium Salt; Indigo carmine; Acid blue	Indigodisulfonate	860-22-0	C <sub>16</sub> H <sub>8</sub> N <sub>2</sub> Na <sub>2</sub> O <sub>8</sub> S <sub>2</sub>	466.35	Acute: no adverse health effects expected from inhalation, ingestion, skin exposure; similar dyes have caused permanent injury to the cornea and conjunctiva in documented exposure cases with human or rabbit eyes. Chronic Exposure: No adverse health effects expected. RTC CLASS OF COMPOUND- Tumorigen; Drug; Mutagen	1250 (93 to 2500)	10 g/L or 0.021 M	-0.13	7, 8, 12
Juglone	5-Hydroxy-1,4-naphthoquinone	481-39-0	C <sub>10</sub> H <sub>6</sub> O <sub>3</sub>	174.15	Acute: Not expected in humans, some irritation in animal studies. Chronic: isomeric juglones stimulated cardiac effects on the isolated frog heart.	NA	Slightly soluble in hot water	0.05	6
Lawson; Natural Brown	2-Hydroxy-1,4-naphthoquinone	83-72-7	C <sub>10</sub> H <sub>6</sub> O <sub>3</sub>	174.15	Acute: slight to moderate skin and mucous membrane irritation, respiratory problems. Chronic: mutagenic in mice/hamster studied, one report deemed it to be not suitable for cosmetic use. RTC CLASS OF COMPOUND - Drug; Mutagen	335 (100 to 570)	up to 2% or 0.115 M	-0.14	9, 15

**Table 1, Continued**  
**Electron Shuttle Chemistry and Toxicity**

Common Name(s)	Chemical Name	CAS No.	Formula	Molecular Weight	Health Hazards Acute and Chronic	LD50 for Mouse/Rat (mg/kg)	Solubility in Water	Standard Potential, Eo (V)	References
Methyl red	Benzoic acid, 2-[[4-(dimethylamino)phenyl]azo]-	493-52-7	C <sub>15</sub> H <sub>15</sub> N <sub>3</sub> O <sub>2</sub>	269.3	Acute: May cause mild irritation to the mucous membranes, large oral doses may cause gastrointestinal disturbances, mild skin irritation. Chronic Exposure: POSSIBLE RISK OF IRREVERSIBLE EFFECTS. LABORATORY EXPERIMENTS HAVE SHOWN MUTAGENIC EFFECTS.	NA	Almost insoluble in water	--	19
Methyl viologen	Methyl viologen	1910-42-5	C <sub>12</sub> H <sub>14</sub> Cl <sub>2</sub> N <sub>2</sub>	257.16	Acute: toxic if swallowed or absorbed through skin, may be harmful in inhaled, causes severe irritation, symptoms may include burning sensation, coughing, wheezing, laryngitis, shortness of breath, headache, nausea, vomiting, high concentrations are extremely destructive to tissues of mucous membranes and upper respiratory tract, eyes and skin. Chronic: may alter genetic material, contains components reported to be carcinogenic.	NA	up to at least 150 uM	-0.446	7, 8
Methylene blue	3,7-Bis(dimethylamino)phenothiazin-5-ium chloride trihydrate	61-73-4	C <sub>16</sub> H <sub>18</sub> ClN <sub>3</sub> S	319.85	This material is relatively non-hazardous in routine industrial situations. Acute: No adverse health effects expected from inhalation, a burning sensation of the mouth may be noted following ingestion of methylene blue, may cause nausea, vomiting, diarrhea, and gastritis, large doses may cause abdominal and chest pain, headache, profuse sweating, mental confusion, painful micturition, and methemoglobinemia, not expected to be a health hazard from skin exposure, may color the skin a bluish color, may cause photosensitization, no adverse effects expected, may cause mechanical irritation. Chronic Exposure: No information found.	NA	40 g/L or 0.125 M	0.011	7, 8
Naphthazarone	5,8-Hydroxy-1,4-naphthoquinone	475-38-7	C <sub>10</sub> H <sub>6</sub> O <sub>4</sub>	190.15	Acute: may cause eye irritation, skin irritation, irritation of the digestive tract, respiratory tract irritation. Chronic: No information found. The toxicological properties of this substance have not been fully investigated.	NA	5.52 g/L	--	17
P-2,6bT	Pyridine-2,6-bis(thiocarboxylate)	NA	NA	NA	NA	NA	NA	NA	2, 4,
Purpurin	1,2,4-Trihydroxyanthraquinone	81-54-9	C <sub>14</sub> H <sub>8</sub> O <sub>5</sub>	256.21	Acute: Causes eye irritation, may cause chemical conjunctivitis, causes skin irritation, may cause gastrointestinal irritation with nausea, vomiting and diarrhea, causes respiratory tract irritation, can produce delayed pulmonary edema. Chronic: Effects may be delayed.	NA	slightly more soluble than Alizarin		13
Ubiquinone, Coenzyme Q10	2,3 dimethyl-5 methyl-6-decaprenyl benzoquinone	303-98-0	C <sub>59</sub> H <sub>90</sub> O <sub>4</sub>	863.34	NA	NA	5.23E-013 mg/L	0.113	2, 5
Vitamin K3, Menadione, Menadione sodium bisulfate, Menaquinone	2-Methyl-1,4-naphthoquinone	58-27-5	C <sub>11</sub> H <sub>8</sub> O <sub>2</sub>	172.18	Acute: causes eye irritation, causes skin irritation, harmful if swallowed, causes respiratory tract irritation. Chronic: Not available. The toxicological properties of this substance have not been fully investigated.	NA	Bisulfate form is freely soluble	-0.20	2, 5,

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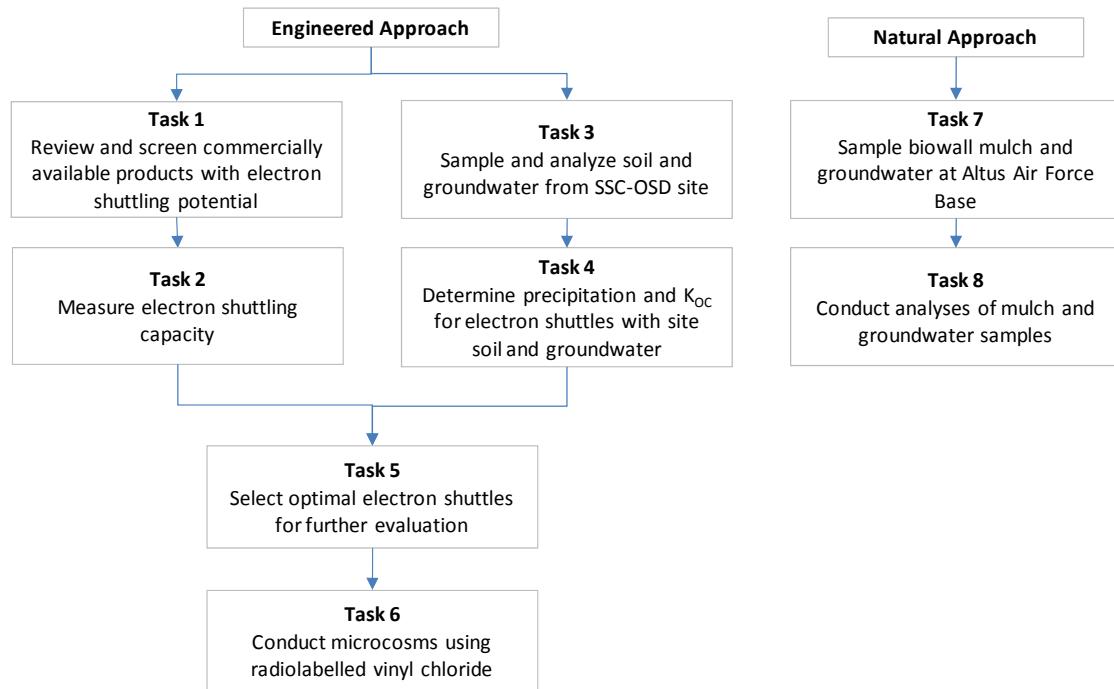
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## 1.3 Project Tasks

The original objective of this study was to validate the role of electron shuttles in stimulating contaminant degradation with a focus on the *cis*-DCE and VC. Two conceptual approaches were planned:

- An engineered approach where an aqueous solution of electron shuttle compounds is injected into the contaminated groundwater and the groundwater is potentially recirculated.
- A natural approach where mulch is used as a source of naturally occurring humic acids that have electron shuttling properties. The mulch is incorporated into biowalls such as those employed by the Air Force for contaminant degradation.

**Figure 3** shows the project tasks associated with the evaluation of these approaches.



**Figure 3 Project Tasks and Relationships**

A brief description of each of these tasks is presented below. Section 2 presents the additional details regarding methodology used to execute the field and laboratory tasks.

### Task 1

Task 1 involved a compilation and review of toxicological information and chemical properties for compounds or substances that have been identified in the scientific literature as having electron shuttling properties. This compilation was presented as **Table 1**. Based on this information, specific compounds were selected for further

evaluation. Compounds that had limited commercial availability, were toxic, had low water solubility, or had limited information were screened out. Compounds that were retained for further evaluation in Task 2 included:

- Humic acids
- Sulfonated humic acids
- Fulvic acids
- Henna
- Menadione sodium bisulfite
- 2,6-Anthraquinone disulfonic acid (AQDS)
- 2-Anthraquinone sulfonic acid (AQS)
- Indigo disulfonate
- Lawsone

## Task 2

Task 2 involved measurement of electron shuttling capacity of the compounds selected in Task 1. The electron shuttling capacity is a quantitative indication of the potential of specific compounds to transfer electrons to ferric iron and cause its reduction to ferrous iron. These measurements were conducted at the University of Massachusetts using a standardized procedure described in Section 2 (Lovley, et al. 1996a; Nevin and Lovley 2002). Humic acids are a complex mixture of compounds with no single chemical structure; therefore, several commercial sources of humic acids were evaluated in this study. Section 2 presents the commercial sources of these products.

## Task 3

Task 3 involved collection of soil and groundwater samples from the Space and Naval Warfare Systems Center Old Town Campus site in San Diego, California (SSC-OTC). SSC-OTC had been selected for a pilot scale demonstration based on site selection criteria, which included accumulation of VC in groundwater and potential for stimulation of biological iron reduction by electron shuttles. Site information is presented in Section 1.4. Additional details on this task are presented in Section 2.

## Task 4

Task 4 involved further evaluation of the electron shuttling compounds evaluated in Task 2. These evaluations were conducted using SSC-OTC soil and groundwater and included evaluation of compound precipitation in site groundwater and soil-water partitioning (i.e.,  $K_{oc}$ ). Additional details on these measurements are presented in Section 2.

## Task 5

Task 5 involved selection of electron shuttling compounds to be tested in a microcosm study (Task 6). Results from Tasks 1, 2, and 4 were used to identify compounds that: a) had the lowest cost per unit of electron shuttling capacity, b) were soluble in site groundwater, and c) had different  $K_{OC}$  values. The selected compounds included:

- 2,6-Anthraquinone disulfonic acid (AQDS)
- Indigo disulfonate
- Monterey Ag Products HA-12 humic acid
- LignoTech Borregro HA-1 sulfonated humic acid.

## Task 6

Task 6 involved a microcosm study conducted by the United States Geological Survey (USGS) to evaluate the fate of radiolabeled VC in the presence of the electron shuttling compounds selected in Task 5. Additional details on this study are presented in Section 2.

## Task 7

Task 7 was conducted by Parsons and involved sampling of biowall solids (i.e., mulch and sand) and groundwater from the biowall located at Altus Air Force Base (AFB) Landfill 3 (LF-3). Groundwater samples were collected upgradient, within, and downgradient of the biowall. Site information is presented in Section 1.4. Additional details on sampling are presented in Section 2 and Appendix B.

## Task 8

Task 8 involved analysis of the biowall and groundwater samples for multiple analytes. Additional description is provided in Section 2. In general, analyses were conducted to characterize the geochemistry and electron shuttling potential within the biowall. The analyses included several standard analyses plus specialized analyses including electron shuttling capacity and bioavailable ferric iron. Additional details on sampling are presented in Section 2 and Appendix B.

## 1.4 Site Descriptions

This section presents an overview of the SSC-OTC and Altus AFB sites. The SSC-OTC site was used for evaluation of the engineered electron shuttle approach, i.e., injection of electron shuttling compounds. Sampling and analysis was conducted specifically to support Tasks 3, 4, and 6 as shown in **Figure 3**. The Altus AFB biowall site was used for evaluation of the natural electron shuttle approach, i.e., presence of humics in the mulch potentially acting as electron shuttles. Sampling and analysis was conducted specifically to support Tasks 7 and 8 as shown in **Figure 3**.

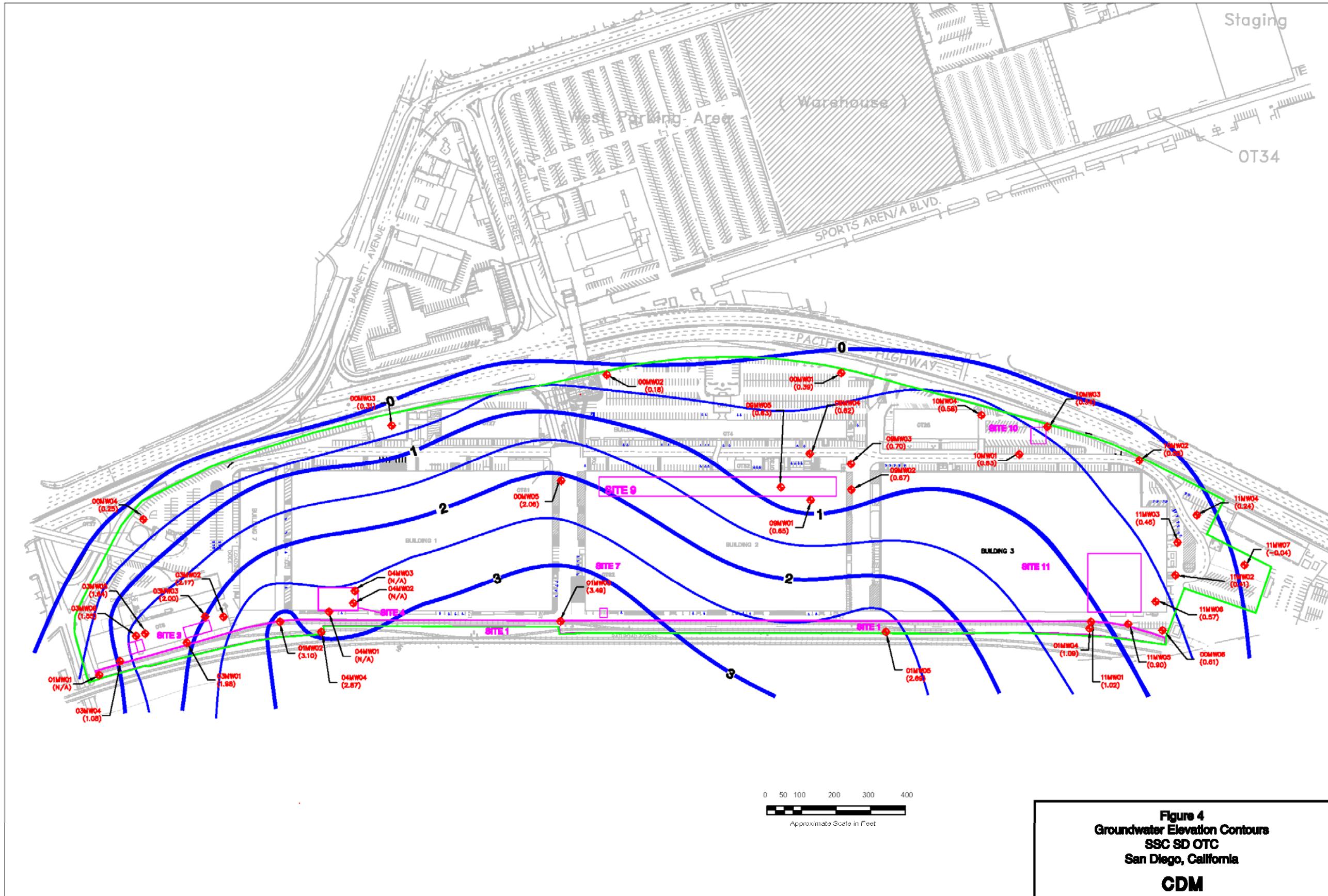
### 1.4.1 SSC-OTC

The SSC-OTC Site consists of approximately 60 acres located at 4297 Pacific Highway in San Diego, California. In the past, fill derived from dredged bay sediments was utilized to construct usable area at the Site. Currently, about 95 percent of the Site is developed, covered with buildings and pavement. Site topography is generally flat with elevations across the site ranging from approximately nine to ten feet above mean sea level (MSL).

**Figure 4** shows an overview of the SSC-OTC Site with groundwater contours. The study was conducted in the vicinity of 11MW07 near Installation Restoration (IR) Site 11. IR Site 11 is located in Building 3 where a former sanitary sewer line break occurred beneath the northeastern area of the building. Processes within the building may have generated waste oil, paint sludge, spent acids, plating materials, degreasing solvents, and Oakite cleaners.

The SSC-OTC Site is located within the Pueblo San Diego Hydrologic Unit, San Diego Mesa Area, Lindbergh Sub area. Historically (Bechtel 2000) local groundwater elevations were measured between 7 and 18 feet below ground surface (ft bgs) or at approximately zero ft MSL. Groundwater flow direction is oriented to the northwest at a gradient of 0.003 ft/ft (Bechtel 2000). Groundwater flow, as indicated by the gradient, is generally to the north to northeast in the demonstration area in IR Site 11.

In general, historical data indicate the presence of high *cis*-DCE and VC concentrations in demonstration area groundwater. TCE was detected in groundwater up-gradient of the demonstration area in well 11GP-22. Gasoline range petroleum hydrocarbons were also detected in groundwater in the vicinity of the demonstration area. Evidence of anaerobic iron reduction is demonstrated by the elevated dissolved iron and manganese concentrations and low oxidation reduction potential. The SSC-OTC site was concluded to be suitable for the demonstration based on presence of *cis*-DCE and VC and evidence of iron reduction.



## 1.4.2 Altus AFB

The Altus AFB mulch biowall was constructed in June 2002 to stimulate reductive dechlorination of chlorinated VOCs in groundwater at Landfill 3 of the site (Henry 2004). This biowall was selected for evaluation in this study based on its demonstrated activity to remove TCE and *cis*-DCE without accumulation of VC.

**Appendix B** includes a simplified plan view of the biowall location. This biowall was constructed to contain and attenuate a shallow groundwater plume contaminated with TCE and *cis*-DCE, in order to prevent surface water discharge or off-base migration. The source of impacts to shallow groundwater at the site is historical waste management activities.

The biowall is composed of shredded bark mulch, cotton gin compost, and sand (to maintain permeability). The mulch and compost substrates are intended to be used as solid-phase, long-term carbon sources to stimulate reductive dechlorination of TCE and its biodegradation products over periods of 5 years or more.

The mulch trench is intended to intercept over 80 percent of the groundwater plume contaminant flux (subject to depth limitations of the trencher). A monitoring well network was installed, including wells upgradient, downgradient, and within the biowall.

### 1.4.2.1 Site Geology

Surface soils in the mulch biowall vicinity consist of approximately 5 feet of clayey silt, and weathered and fractured stiff silty clay that extends to depth of approximately 25 to 30 ft bgs. These sediments are underlain by well-cemented silt and dense shale of the Hennessey Group of Permian age. Shallow groundwater occurs under unconfined conditions and generally flows towards the east-southeast to Stinking Creek. Shallow groundwater at the site occurs at a seasonally variable depth of approximately 6 to 12 ft bgs. The groundwater surface slopes toward the southeast with an average horizontal hydraulic gradient of approximately 0.003 ft/ft.

Through March 2003, the mulch biowall had caused measurable changes in groundwater geochemistry supportive of reductive dechlorination (Henry, 2004). Groundwater dissolved oxygen (DO) has been depleted and sulfate has been reduced. Sulfate has been reduced to 17 to 300 milligrams per liter (mg/L) with a pre-installation background level of 1,400 to 2,200 mg/L. Oxidation-reduction potential (ORP) in the biowall and immediately downgradient has been lowered to -212 millivolts (mV) to -325 mV. Methane levels in the biowall are elevated at concentrations of 7.0 to 8.8 mg/L.

The primary contaminants of concern (COCs) at the site are TCE and its daughter products. Since installation of the mulch biowall, TCE levels in the biowall have decreased by up to 98 percent to less than 2 micrograms per liter ( $\mu\text{g}/\text{L}$ ). TCE levels downgradient of the biowall have decreased from a range of 190 to 2,500  $\mu\text{g}/\text{L}$  to a range of 2.6 to 2,000  $\mu\text{g}/\text{L}$ . For all monitoring locations downgradient of the biowall, the average decrease in TCE has been 60 percent. While concentrations of *cis*-DCE

increased in many locations over the same period, the concentration of *cis*-DCE subsequently declined without an accumulation of VC. Concentrations of *cis*-DCE range from 42 to 1,500 µg/L within and downgradient of the biowall, with the lower concentrations closer to wall. Other chlorinated solvents present are typically below drinking water standards.

# Section 2

## Materials and Methods

This section describes materials and methods used in support of the study tasks outlined in **Figure 3**.

### 2.1 Task 1 - Electron Shuttle Screening

**Table 1** included the various electron shuttling compounds that were considered for further evaluation. Various factors including commercial availability, toxicity, water solubility, and availability of information were used to screen the compounds. Various commercial sources for potential electron shuttling compounds were identified. **Table 2** lists the compounds that were evaluated in subsequent tasks and **Appendix C** includes additional information regarding the sources of these materials. These compounds included various humic and fulvic acid products plus pure chemical compounds. Prices for these materials were also obtained and were used to calculate unit costs that were normalized with respect to electron shuttling capacity as described in Section 3.

### 2.2 Task 2 - Electron Shuttling Assays

The 21 electron shuttling compounds listed in **Table 2** were evaluated by an electron shuttle bioassay (Lovley, et al. 1996a; Nevin and Lovley 2002). The bioassay was developed by Dr. Derek Lovley and involves microbial reduction of the electron shuttling compounds followed by incubation of the reduced electron shuttle with ferric citrate. Ferric iron reduction to ferrous iron is measured and is used as a quantitative measurement of electron accepting capacity of the electron shuttle. Electron shuttling capacity is measured in units of millimoles per liter (mM) of iron reduced and then compared to the capacity for a well-characterized soil humic acid standard obtained from the International Humic Substances Society (IHSS). The IHSS standard is known to shuttle electrons (Lovley, et al. 1996a; Nevin and Lovley 2002). Electron shuttling capacity is then reported as a percentage of that for the IHSS material.

The humic/fulvic acids, henna products, and AQS (refer to **Table 2**) were evaluated at a concentration of 1 g/L. Liquid products were tested at a concentration of 1 g/L based on the humic/fulvic acid solids content in the liquid. The 15% Concentrated Liquid Humus provided by Humus Products of America was added at a concentration of 6.7% by volume to obtain an effective humic acid in the test of 1 g/L. The remaining electron shuttles (i.e., AQDS, lawsone, indigo sulfonate, and menadione sodium bisulfate) were added at a concentration of 0.1 g/L. Different concentrations were selected for this test to attain an approximately equivalent economic basis. The pure chemical products are significantly more expensive than the humic/fulvic acid and henna products.

**Table 2**  
**Evaluated Electron Shuttles**

No.	Supplier	Product	Form	Humic Acid	Fulvic Acid	Source	Unit cost	Unit cost basis
1	TeraVita	SP-85	85% soluble solid	80	5	Leonardite	\$ 8.02	lb
2	Luscar Ltd	Dry Soluble 80	100% soluble solid	38	17	Subbituminous coal	\$ 2.50	lb
3	Luscar Ltd	Liquid 12000	12% Liquid	8.3	3.7	Subbituminous coal	\$ 2.65	gal
4	Triad	Huma K	100% soluble solid	56	30	Leonardite	\$ 3.00	lb
5	Live Earth Products	12% Liquid Humic Acid	12% Liquid	10	2	Humic shale	\$ 6.50	gal
6	Monterey AgResources	HA-12	12% Liquid	9	3	Leonardite	\$ 7.50	gal
7	Humate International	Humate AS	100% soluble solid	75	25	Leonardite	\$ 8.64	lb
8	Humus Products of America	15% Concentrated Liquid Humus	15% Liquid	NA	NA	Leonardite	\$ 11.00	gal
9	LignoTech	BorreGro HA-2	100% soluble solid	50	20	Leonardite	\$ 3.26	lb
10	LignoTech	BorreGro HA-1	100% soluble solid	50	20	Modified leonardite	\$ 2.88	lb
11	Horizon Ag Products	Quantum H	7% Liquid	6.9	0.1	Leonardite	\$ 3.75	gal
12	UAS America	Super Hume	17% Liquid	3	14	Leonardite	\$ 3.90	gal
13	Northwest Agricultural Products	Ful-Vac 3	3% Liquid	0	3	Leonardite	\$ 3.00	gal
14	Natural Resources Group	F Power 10%	10% Liquid	0	10	Leonardite	\$ 7.75	gal
15	Humatech	Aqua F	Liquid	0	3	NA	NA	gal
16	Henna Global Wholesale	Henna	Paste	NA	NA	Plant origin	\$ 17.27	lb
17	Spectrum	Menadione sodium bisulfite	Powder	NA	NA	Pure chemical	\$ 181.36	lb
18	Acros Fisher	26AQDS	Powder	NA	NA	Pure chemical	\$ 127.12	lb
19	Spectrum	2AQS	Powder	NA	NA	Pure chemical	\$ 10.53	lb
20	Spectrum	Indigo disulfonate	Powder	NA	NA	Pure chemical	\$ 217.92	lb
21	Acros Fisher	Lawson	Powder	NA	NA	Pure chemical	\$ 175.26	lb

Note:

NA - not applicable or available.

All tests were conducted in duplicate. Electron shuttling capacity for each compound was compared to that of a well characterized humic acid standard (i.e., International Humic Substance Society (IHSS) soil humic acids).

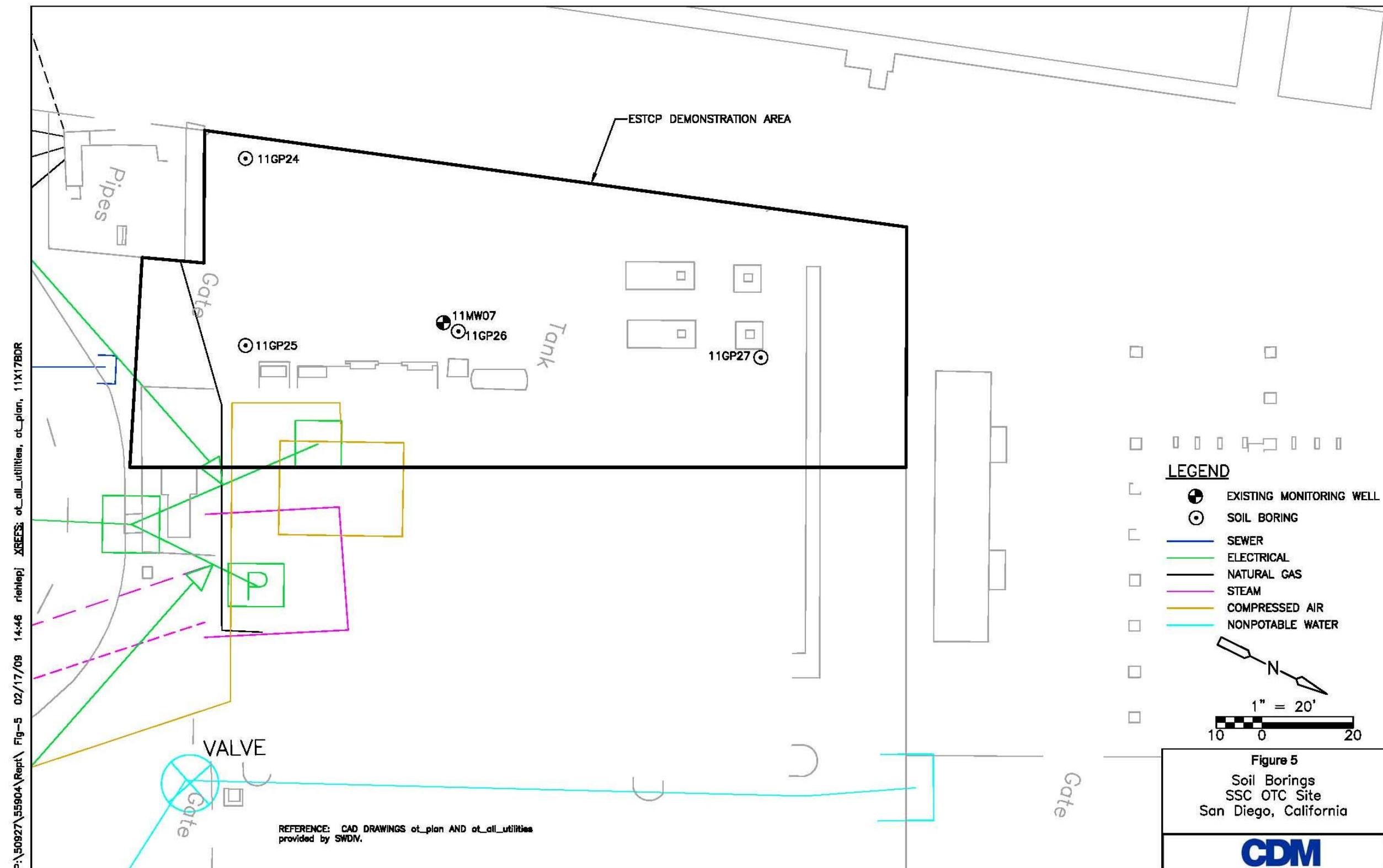
## 2.3 Task 3 – SSC-OTC Sample Collection and Analysis

**Figure 5** shows the sample locations for soil and groundwater and **Table 3** shows the analyses that were conducted on each of the samples. Soil samples were collected continuously from 10 to 25 ft bgs using direct push technology. The Unified Soil Classification System (USCS) was used to describe soil types. Lithologic observations were conducted as quickly as practicable to minimize exposure of the samples to air which would compromise the Treatability Study objectives. Composite soil samples for laboratory analysis and treatability studies were collected within the saturated zone of each borehole. Once the sample interval was retrieved, soil samples were extracted from the acetate sleeves and homogenized in a stainless steel bowl. Homogenized soil samples were then containerized in glass jars and labeled for delivery to the appropriate analytical laboratory. Groundwater from the soil boring was poured over the soil prior to sealing the jars to minimize oxygen exposure.

One depth-discrete groundwater sample was collected at each of the direct push locations correlating to the soil borings using low-flow sampling. The samples collected from the existing monitoring well 11MW07 were from an approximate depth of 15 ft bgs correlating to the approximate middle of the screened interval. Groundwater was sampled from the boreholes and well using a peristaltic pump at a flow rate of about 300 milliliters per minute (mL/min) or at a flow rate that resulted in less than 5 percent drawdown of the static water level. Field meters were used to monitor dissolved oxygen, pH, temperature, conductivity, turbidity, and oxidation-reduction potential in the groundwater and recorded on a groundwater purge and sample form. Dissolved oxygen, sulfide, total and ferrous iron measurements were conducted using field test kits.

Following purging of the boring location or monitoring well, groundwater samples were collected. Groundwater samples collected for dissolved metals analyses were filtered through a 0.45-micron filter. Unfiltered groundwater samples were collected for the remaining analyses. Groundwater samples were collected in the appropriate sampling containers with preservatives for the analyses as described in the work plan (CDM 2005). This work plan was a modification of a previous work plan that was submitted to ESTCP (CDM 2004).

Samples were analyzed for conventional parameters by Applied P & CH Laboratories in Chino, California. Bioavailable ferric iron analysis was conducted by CDM using the bioavailable ferric iron assay validated in ESTCP project number ER0009 (NAVFAC 2005).



**Table 3**  
Sampling and Analysis Schedule for SSC-OTC Site

Location	Location Type	Depth	Sample Matrix	pH, Temperature, Conductivity, Turbidity, ORP, Dissolved Oxygen	Dissolved Oxygen, Ferrous Iron, Sulfide	Volatile Organic Compounds	Total Petroleum Hydrocarbons	Dissolved Fe, Mn, As, V	Total Fe, Mn, As, V	Br, Cl, NO <sub>3</sub> , NO <sub>2</sub> , PO <sub>4</sub> , SO <sub>4</sub>
				Field probe	Field test kit	EPA 8260B	EPA 8015	EPA 6000 series	EPA 6000 series	EPA 300 series
11MW07	Existing Well	10 - 20 feet	groundwater	1	1	1	1	1		1
11GP24	New geoprobe	0 - 25 feet	saturated soil						1	
11GP24	New geoprobe	0 - 25 feet	groundwater	1	1	1	1	1		1
11GP25	New geoprobe	0 - 25 feet	saturated soil						1	
11GP25	New geoprobe	0 - 25 feet	groundwater	1	1	1	1	1		1
11GP26	New geoprobe	0 - 25 feet	saturated soil						1	
11GP26	New geoprobe	0 - 25 feet	groundwater	1	1	1	1	1		1
11GP27	New geoprobe	0 - 25 feet	saturated soil						1	
11GP27	New geoprobe	0 - 25 feet	groundwater	1	1	1	1	1		1

**Table 3, Continued**  
**Sampling and Analysis Schedule for SSC-OTC Site**

Location	Location Type	Depth	Sample Matrix	Hardness	Total Dissolved Solids	Methane, Ethane, Ethene	Total Organic Carbon	Bioavailable Ferric Iron	Adsorption Treatability Study	Microcosm Treatability Study
				EPA 200.7	EPA 160.1	AM18, AM20GAX, or RSK175	EPA 415.1 or SW9060	CDM	CDM	USGS
11MW07	Existing Well	10 - 20 feet	groundwater	1	1	1	1		1	1
11GP24	New geoprobe	0 - 25 feet	saturated soil				1	1	1	1
11GP24	New geoprobe	0 - 25 feet	groundwater	1	1	1	1			
11GP25	New geoprobe	0 - 25 feet	saturated soil				1	1	1	
11GP25	New geoprobe	0 - 25 feet	groundwater	1	1	1	1			
11GP26	New geoprobe	0 - 25 feet	saturated soil				1	1	1	1
11GP26	New geoprobe	0 - 25 feet	groundwater	1	1	1	1			
11GP27	New geoprobe	0 - 25 feet	saturated soil				1	1	1	1
11GP27	New geoprobe	0 - 25 feet	groundwater	1	1	1	1			

## 2.4 Task 4 – Precipitation and K<sub>OC</sub> Assessment

Treatability studies were conducted using the electron shuttling products listed in **Table 2** in combination with soil and ground water collected from the SSC-OTC site. The studies included evaluation of the potential for product precipitation in site groundwater and development of adsorption isotherms.

Precipitation was evaluated by adding known concentrations of product to groundwater and mixing to dissolve. The solution or mixture was allowed to stand overnight and visual observations of precipitation were made.

The soil-water distribution coefficients of the electron shuttling compounds was conducted by setting up electron shuttle solutions in groundwater at concentrations of 0.00, 0.01, 0.1, 1.0, and 10 g/L. Soil was added to each of these solutions at a nominal concentration of 1 g/L. The bottles were shaken at room temperature and water samples were withdrawn and filtered after 24 and 48 hours. The electron shuttle concentration was measured spectrophotometrically. An adsorption isotherm was prepared for each electron shuttle compound based on the results.

## 2.5 Task 5 – Electron Shuttle Selection

Results from Tasks 1, 2, and 4 were used to identify compounds that had the lowest cost per unit electron shuttling capacity, were soluble in site groundwater, and had different K<sub>OC</sub> values. This task did not involve field sampling, analysis, or experimental work and is not described further.

## 2.6 Task 6 – Microcosms

Vinyl chloride transformation was measured in SSC-OTC soil and groundwater and in the presence of selected electron shuttling compounds by Drs. Paul Bradley and Frank Chapelle of the United States Geological Survey (USGS).

The products of anoxic vinyl chloride biodegradation were investigated using [1,2-<sup>14</sup>C] VC (1.6  $\mu$ Ci/ $\mu$ mole; Perkin Elmer Life Sciences, Boston, Massachusetts). Authentic H<sup>14</sup>CO<sub>3</sub><sup>-</sup> (Sigma Biochemicals, St. Louis, Missouri), <sup>14</sup>CH<sub>4</sub> (Perkin Elmer Life Sciences, Boston, Massachusetts), and [1,2-<sup>14</sup>C] ethene (Moravek Biochemicals, Inc., Brea, California) were used as radiolabeled standards for calibration and methods development. The radiochemical purity of the <sup>14</sup>C-stocks was evaluated by direct injection radiometric detection gas chromatography (GC/RD) and found to be greater than 98% pure.

Microcosm studies were conducted as summarized below (Bradley and Chapelle 1999a, 1999b, 2000). In general, sediment microcosms were 10-mL serum vials with 5 $\pm$ 0.5 g of saturated sediment and an atmosphere of nitrogen. Microcosms were assembled under an atmosphere of nitrogen and subsequently flushed three separate times with 100 times the headspace volume of pure nitrogen. Soil from boring 11GP27 was used for the microcosms because it was collected in the vicinity of the highest recorded *cis*-DCE and VC concentrations in groundwater. Groundwater was

collected from monitoring well 11MW07 because it was the only developed monitoring well in the area.

Five organic electron shuttle treatments were assessed: groundwater control, AQDS, indigo carmine, Monterey Humic Acids, and Ligno Tech Humic Acids HA-1. Each organic electron shuttle compound was assessed at three shuttle concentration treatments over a concentration range of three orders of magnitude. **Table 4** presents the electron shuttle microcosm conditions evaluated in this study.

Triplicate experimental microcosms, duplicate autoclaved control microcosms, and a single sediment-free container control microcosm were prepared for each sediment treatment. All controls were autoclaved three times for 1 h at 15 psig and 121 °C. All microcosms were pre-incubated in the dark for five days prior to the addition of <sup>14</sup>C-substrates. Microcosms were amended with <sup>14</sup>C-VC to yield initial dissolved substrate concentrations of approximately 120 µg/L. All treatments were incubated in the dark at room temperature (23 °C) for 190 days. Anoxic conditions (headspace [O<sub>2</sub>] < 10 µM) were confirmed throughout the studies by headspace sampling and gas chromatography with thermal conductivity detection.

Headspace concentrations of CH<sub>4</sub>, <sup>14</sup>CH<sub>4</sub>, CO<sub>2</sub>, <sup>14</sup>CO<sub>2</sub>, ethene, <sup>14</sup>C-ethene, ethane, <sup>14</sup>C-ethane, VC, and <sup>14</sup>C-VC were monitored by analyzing 0.5 ml of headspace using packed column gas chromatography with radiometric and thermal conductivity detection (Bradley and Chapelle 1999a, 1999b, 2000, 2002). The headspace sample volumes were replaced with pure nitrogen. Dissolved phase concentrations of <sup>14</sup>C-analytes were estimated based on experimentally determined Henry's partition coefficients. The radiometric detector was calibrated by liquid scintillation counting using H<sup>14</sup>CO<sub>3</sub><sup>-</sup>.

## 2.7 Task 7 - Altus AFB Sampling

Soil and groundwater sampling at the Altus AFB was conducted by Parsons. Parsons collected samples in accordance with existing protocols for the Altus AFB. Sampling consisted of collecting soil/mulch samples from two exploratory borings within the mulch biowall and groundwater samples from monitoring wells located within, upgradient, and downgradient of the mulch biowall: OU-1-05, PES-MP-1, PES-MP-2, WL019, PES-MP-6, and PES-MP-7. Soil borings SB-1 and SB-2 were completed in the northern and southern portions of the much wall, respectively. Additional details are presented in **Appendix B**.

**Table 4**  
**Microcosm Set-Up**

Electron Shuttle	Product Concentration	Electron Accepting Capacity (% of IHSS Soil HA) <sup>a</sup>	Koc (L/kg)	100% Baseline Conc. (g/L)	10% of Baseline Conc.			100% of Baseline Conc.			1000% of Baseline Conc.		
					Shuttle	Added Shuttle <sup>b</sup> (mg product)	Equilibrium Concentration (mg/L)	Shuttle	Added Shuttle <sup>b</sup> (mg product)	Equilibrium Concentration (mg/L)	Shuttle	Added Shuttle <sup>b</sup> (mg product)	Equilibrium Concentration (mg/L)
2,6-Anthraquinone disulfonic acid, sodium salt (AQDS)	100% Solid	360	NA	0.21	0.063	0.063	NA	0.63	0.63	NA	6.3	6.3	NA
Indigo disulfonate (Indigo Carmine aka FD&C Blue #2)	100% Solid	400	3.5	0.19	0.057	0.057	2.8	0.57	0.57	28	5.7	5.7	277
Monterey Ag Products HA-12 12% humic acid	12% wt solution	49	50	1.5	0.46	3.9	1.8	4.6	39	18	46	386	183
LignoTech Borrego HA-1 (Sulfonated Humic acid)	100% Solid	14	5.8	5.4	1.6	1.6	51	16.2	16.2	506	162	162	5063

Notes:

a) In the case of humic acid solutions, activity is based on humic acid mass, not on solution mass. IHSS soil humic acids had 100% activity by definition.

b) Calculated amount of electron shuttle product (solid or liquid) to be added per microcosm. Based on equal electron accepting capacity per bottle.

NA - not applicable or available.

HA - humic acid.

IHSS - International Humic Substance Society.

Koc - organic carbon partition coefficient.

g/L - grams per liter.

L/kg - liters per kilogram.

mg - milligrams.

## 2.8 Task 8 – Altus AFB Sample Analysis

Analyses of biowall materials included:

- Total organic carbon (TOC) (Method SW9060)
- Volatile organic compounds (VOCs) (EPA Method 8260B)
- Total sulfide, iron (II) sulfide, and iron monosulfide (Microseeps)
- Bioavailable ferric iron (New Horizon Diagnostics Corp. test kit)
- Electron shuttle bioassay (University of Massachusetts)

Analyses of groundwater samples included:

- Total organic carbon (TOC) (Method SW9060)
- Volatile organic compounds (VOCs) (EPA Method 8260B)
- Methane, ethane, and ethene (AM-20GAX)
- Nitrate plus nitrite (EPA 353.1)
- Sulfate and chloride (EPA 300.1)
- Volatile fatty acids (Microseeps)
- Total dissolved solids (EPA 160.3)
- Hardness (EPA 130.2)
- Field measurements including pH, temperature, conductivity, turbidity, oxidation-reduction potential, dissolved oxygen, and ferrous iron, hydrogen sulfide, and alkalinity

In addition, the biowall samples were analyzed for electron shuttling capacity at the University of Massachusetts using procedures described in Section 2.2. The samples were tested at a concentration of 1 g/L.

Additional details are presented in **Appendix B**.

# Section 3

## Results and Discussion

### 3.1 SSC-OTC Sampling and Analysis

**Table 5** summarizes analytical results for soil and groundwater samples collected at the SSC-OTC Site in accordance with Task 3. **Appendices D** and **E** include soil boring logs and analytical data reports, respectively.

**Table 5**  
SSC-OTC Results

Analyte in Groundwater	11GP24	11GP25	11MW07	11GP26	11GP27
Tetrachloroethene (µg/L)	<25	<5	<0.5	<25	<13
Trichloroethene (µg/L)	<25	<5	<0.5	<25	<13
cis-1,2-Dichloroethene (µg/L)	8,670	272	1,000	3,140	4,510
Vinyl Chloride (µg/L)	1,520	174	613	935	2,700
Ethene (µg/L)	31	28	130	28	89
Dissolved Oxygen (mg/L)	0.6	1	0.6	0.4	0.6
Nitrate (mg-N/L)	0.14	0.068 J	0.21	<0.1	0.59
Manganese (mg/L)	0.408	0.504	0.561	0.461	0.461
Iron (mg/L)	2.11	2.3	3.97	2.8	0.0346 J
Sulfate (mg/L)	557	690	590	560	388
Sulfide (mg/L)	<1	<1	<1	<1	<0.11
Methane (µg/L)	160	99	140	160	200
Oxidation-Reduction Potential (mV)	-236	-221	-172	-212	-80
<b>Analyte in Soil</b>		<b>11GP24 (10-20 ft)</b>	<b>11GP25 (10-22 ft)</b>	<b>11GP26 (10-22 ft)</b>	<b>11GP27 (14-22 ft)</b>
Total Organic Carbon avg. (mg/kg)	400	2970		660	636
Iron (mg/kg)	9,830	11,000		6,230	4,300
Bioavailable Ferric Iron (mg/kg)	1,400 (910)	1,700 (910)		1,300 (1,500)	630 (630)

Notes:

Numbers in parentheses are duplicate results.

µg/L - micrograms per liter.

mg/L - milligrams per liter.

mg-N/L - milligrams nitrogen per liter.

mV - millivolts.

mg/kg - milligrams per kilogram.

J - estimated value.

< - analyte not detected at or greater than the listed concentration.

ft - feet below ground surface

Groundwater concentrations of *cis*-DCE and VC increased along the groundwater flow path from 11GP25 to 11GP27. PCE and TCE concentrations were below detection limits and *cis*-DCE and VC concentrations were elevated (e.g., up to 8,670 µg/L *cis*-DCE and up to 2,700 µg/L VC) indicating that complete reductive dechlorination was not occurring. Additionally, dissolved ethene concentrations were low further indicating that complete reductive dechlorination may not be occurring.

Dissolved oxygen and nitrate concentrations were generally low. Dissolved iron concentrations ranged from 2 to 4 mg/L except at 11GP27 that had an estimated concentration of 0.0346 mg/L. Sulfate concentrations were high (e.g., up to 690 mg/L), methane concentrations were relatively low (e.g., up to 200  $\mu$ g/L), and the oxidation-reduction potential was low (e.g., - 236 mV) suggesting that sulfate reduction may be occurring. However, sulfide was not detected. Thus the aquifer appeared to be predominately iron-reducing but could have been sulfate reducing. Significant bioavailable ferric iron was also present in site soil to support further iron reduction.

### 3.2 Altus AFB Sampling and Analysis

Parsons conducted the sampling and analysis of the Altus AFB biowall as part of Tasks 7 and 8; however, ER0316 was cancelled prior to completion of any data development and interpretation. The following data summary is presented for informational purposes:

- In the northern flow path, TCE, *cis*-DCE, VC, and ethene concentrations were 1,500, 550, < 100, 0.071  $\mu$ g/L upgradient of the biowall, respectively. The concentrations of these constituents in the biowall were and < 12, 69, 590, and 3.3  $\mu$ g/L, respectively. This change reflects a 41 percent reduction in total molar concentration (non-detected concentrations were assumed to be half the practical quantitation limit).
- In the southern flow path, TCE, *cis*-DCE, VC, and ethene concentrations were 74, 73, <2.5, 0.036  $\mu$ g/L upgradient of the biowall, respectively. The concentrations of these constituents in the biowall were and 5.8, 85, 3.0, and 0.27  $\mu$ g/L, respectively. This change reflects a 26 percent reduction in total molar concentration (non-detected concentrations were assumed to be half the practical quantitation limit).
- Relative electron shuttling capacity ranged from 0 to 79 percent of the 0.5 g/L humic acids standard. The relative electron shuttling capacity in the northern flow path biowall samples were greater than that of the southern flow path samples. The relative electron shuttling capacity of the northern flow path samples ranged from 47 to 79 percent. The relative electron shuttling capacity of the southern flow path biowall samples ranged from 0 to 33 percent.
- Bioavailable ferric iron (BAFeIII) ranged from < 6.4 to 650 mg/kg. BAFeIII in the northern flow path biowall samples were greater than that of the southern flow path samples. BAFeIII of the northern flow path samples ranged from 440 to 650 mg/kg. BAFeIII of the southern flow path biowall samples ranged from < 6.4 to 290 mg/kg.

A complete data report is presented in **Appendix B**.

### 3.3 Electron Shuttle Screening and Characterization

**Table 6** presents characterization results for the various electron shuttle products. The results presented in **Table 6** are based on results from Tasks 1, 2, and 4. Economic comparisons are also included in this table. Products 1 through 16 are different humic acid or fulvic acid products. Products 17 through 21 are pure chemicals. The commercial prices and the vendor-reported humic acid/fulvic acid contents or chemical purities were used to calculate the cost per pound of reported active material. The humic acid/fulvic acid products ranged from \$3 to \$17/lb of reported active material. The pure products ranged from \$127 to \$313/lb of reported active material with the exception of AQS which was \$11/lb.

Aldrich humic acids were not evaluated because Sigma-Aldrich was not willing to sell the product for injection into groundwater due to liability concerns. Specifically, they stated (email from John Green, July 22, 2002):

*We cannot sell this material for your application due to concerns by our company of possible issues that may arise with its use in the environment. This is not to say that the material could not be used in a safe manner that would cause no effects on the environment, but Sigma-Aldrich does not feel that it is in our best interest to sell this material to you for your intended use at this time.*

While Aldrich humic acids have been used extensively in laboratory studies, their commercial unavailability is an important factor to consider when translating academic findings into field applications.

The reported humic acid content is not necessarily a good indicator of electron shuttling capacity. Electron shuttling capacity is defined as the specific ability of a compound to be reduced by iron-reducing bacteria and, in turn, oxidize ferric ion to ferrous ion. A specialized analysis for "electron shuttling capacity" has been developed by the University of Massachusetts as was conducted under Task 2. The electron shuttling capacity for each compound was determined and compared to a humic acid standard. The relative activity (i.e., relative to the humic acid standard) for products 1 through 16 ranged from 6 to 40%. Menadione sodium bisulfate (Product 17) showed no activity. This product is the soluble version of vitamin K3 which is known to have electron shuttling ability. Thus, bisulfate modification resulted in loss of activity. AQS and lawsone (Products 19 and 21) were similar to the humic acid/fulvic acid products with relative activities of 20% and 41%, respectively. AQDS had a very high relative activity of 362% as expected. Unexpectedly, indigo disulfonate had the highest relative activity at 399%. This product is a registered food colorant (FD&C Blue Number 2 also known as indigo carmine) and thus would appear to have good potential for use as an electron shuttle because of high electron shuttling capacity and safety.

**Table 6**  
**Electron Shuttle Results**

No.	Supplier	Product	Form	Humic Acid (%)	Fulvic Acid (%)	Unit cost	Unit cost basis	Specific Cost (\$/lb reported active material)	Specific cost basis	Shuttling Capacity % of 0.5 g/L IHSS Soil Humic Acid standard	Relative activity (to IHSS humic acids)	Normalized cost (\$/lb electron shuttling compounds)	Koc (L/kg)	Tested Conc. in Groundwater (g/L)	Soluble in Groundwater at Tested Conc.?
1	TeraVita	SP-85	85% soluble solid	80	5	\$ 8.02	lb	\$ 10	HA	79	40%	\$ 20	48	1.1	N
2	Luscar Ltd	Dry Soluble 80	100% soluble solid	38	17	\$ 2.50	lb	\$ 7	HA	76	38%	\$ 7	75	0.5	N
3	Luscar Ltd	Liquid 12000	12% Liquid	8.3	3.7	\$ 2.65	gal	\$ 4	HA	59	30%	\$ 9	120	1.0	N
4	Triad	Huma K	100% soluble solid	56	30	\$ 3.00	lb	\$ 5	HA	63	32%	\$ 9	61	0.7	N
5	Live Earth Products	12% Liquid Humic Acid	12% Liquid	10	2	\$ 6.50	gal	\$ 7	HA	76	38%	\$ 17	87	1.2	N
6	Monterey AgResources	HA-12	12% Liquid	9	3	\$ 7.50	gal	\$ 10	HA	98	49%	\$ 15	50	1.0	Y
7	Humate International	Humate AS	100% soluble solid	75	25	\$ 8.64	lb	\$ 12	HA	57	28%	\$ 30	NT	0.6	N
8	Humus Products of America	15% Concentrated Liquid Humus	15% Liquid	NA	NA	\$ 11.00	gal	NA	HA	51	25%	\$ 35	66	1.0	N
9	LignoTech	BorreGro HA-2	100% soluble solid	50	20	\$ 3.26	lb	\$ 6	HA	55	28%	\$ 12	95	1.2	N
10	LignoTech	BorreGro HA-1	100% soluble solid	50	20	\$ 2.88	lb	\$ 7	HA	27	14%	\$ 21	5.8	1.1	Y
11	Horizon Ag Products	Quantum H	7% Liquid	6.9	0.1	\$ 3.75	gal	\$ 6	HA	68	34%	\$ 19	NT	0.5	N
12	UAS America	Super Hume	17% Liquid	3	14	\$ 3.90	gal	\$ 3	FA	36	18%	\$ 15	76	0.5	Y
13	Northwest Agricultural Products	Ful-Vac 3	3% Liquid	0	3	\$ 3.00	gal	\$ 11	FA	16	8%	\$ 153	NT	0.5	Y
14	Natural Resources Group	F Power 10%	10% Liquid	0	10	\$ 7.75	gal	\$ 9	FA	12	6%	\$ 159	NT	1.0	N
15	Humatech	Aqua F	Liquid	0	3	NA	gal	NA	NA	17	9%	NA	NT	NA	NA
16	Henna Global Wholesale	Henna	Paste	NA	NA	\$ 17.27	lb	\$ 17	NA	38	19%	\$ 91	NT	0.6	N
17	Spectrum	Menadione Sodium Bisulfite	Powder	NA	NA	\$ 181.36	lb	\$ 181	Chemical	0.0	0%	NA	NT	NA	NA
18	Acros Fisher	AQDS	Powder	NA	NA	\$ 127.12	lb	\$ 127	Chemical	72	362%	\$ 35	NT	0.6	N
19	Spectrum	AQS	Powder	NA	NA	\$ 10.53	lb	\$ 11	Chemical	40	20%	\$ 53	NT	0.6	N
20	Spectrum	Indigo Disulfonate	Powder	NA	NA	\$ 217.92	lb	\$ 218	Chemical	80	399%	\$ 55	3.5	0.6	Y
21	Acros Fisher	Lawsone	Powder	NA	NA	\$ 175.26	lb	\$ 313	Chemical	8.3	41%	\$ 424	NT	NA	NA

Notes:

NA - not applicable or available.

NT - not tested.

HA - humic acid.

FA - fulvic acid.

IHSS - International Humic Substance Society.

Koc - organic carbon partition coefficient.

g/L - grams per liter.

lb - pounds.

L/kg - liters per kilogram.

The electron shuttling capacity was used to calculate the unit cost of each product. These unit costs are reported in units of dollars per pound of electron shuttling compounds and is defined as the actual product cost divided by the relative activity (to IHSS humic acids). The results indicate humic acid Products 1 to 12 ranged in unit cost from \$7 to \$21/lb and the two fulvic acid products were \$153 and \$159/lb. Henna was \$91/lb. The pure products AQDS, AQS, and indigo disulfonate were slightly more expensive than the humic acid products and ranged from \$35 to \$55/lb. Lawsone was much more expensive with a unit cost of \$424/lb.

The humic acid products varied in unit price by a factor of three following normalization with respect to electron shuttling activity. AQDS and indigo disulfonate were more expensive than the humic acids even though they had a very high specific activity. Nevertheless, further evaluation of indigo disulfonate was warranted because of its registration as an FD&C food colorant. Additionally, its high specific activity relative to IHSS humic acids indicates that less compound would need to be injected into the ground.

The soil-water partitioning coefficient ( $K_{OC}$ ) is important with respect to transport of compounds through an aquifer. The soil-water partitioning coefficients and the qualitative solubility of these compounds were evaluated as part of Task 4 using soil and groundwater collected from the SSC-OTC Site as part of Task 3. The  $K_{OC}$  values of the humic acid products ranged from 48 to 120 L/kg with the exception of Product 10 which is a sulfonated derivative of humic acids and had a  $K_{OC}$  of 5.8 L/kg. Indigo disulfonate was similar with a  $K_{OC}$  of 3.5 L/kg. Supporting data are presented in **Appendix F**.

While many of the humic acid products were reported to be 10% soluble, many were observed to partially precipitate in Site groundwater. This finding indicates that commercial products should be evaluated for compatibility with Site groundwater to ensure that precipitation does not occur following injection.

### 3.4 Electron Shuttle Selection

Based on the results presented in Section 3.3 in accordance with Task 5, Product 6 (Monterey Ag-Resources HA-12 humic acids), Product 10 (LignoTech Borrego HA-1 sulfonated humic acids), and Product 20 (indigo disulfonate) were selected for evaluation in the vinyl chloride microcosm study. Product 6 was selected as a standard humic acid that remained in solution in groundwater. Product 10 was selected because of its lower  $K_{OC}$  value. Product 20 was selected because it is a non-humic acid product that has a high electron shuttling capacity. Product 18 (AQDS) was also used for comparison because of its previously demonstrated ability to shuttle electrons and promote vinyl chloride transformation (Bradley, et al. 1998).

### 3.5 Microcosm Results

Task 6 was conducted by USGS (Drs. Frank Chapelle and Paul Bradley) and demonstrated little to no effect of electron shuttles on oxidative or reductive VC

biodegradation. Analysis of select microcosms from each treatment was performed at approximately 30 days incubation to determine if a complete time-point assessment was appropriate. No evidence of  $^{14}\text{C}$ -VC loss or accumulation of  $^{14}\text{C}$ -products was observed in any treatment. It was concluded that the biodegradation activity was low or insignificant and a full time-point analysis was not appropriate.

A complete time point assessment was conducted after approximately 95 days of incubation. No evidence of significant  $^{14}\text{C}$ -VC loss or accumulation of  $^{14}\text{C}$ -products was observed. It was again concluded that oxidative or reductive biodegradation activity was either absent or low in this sediment under these incubation conditions. It was decided to conduct another full time-point at approximately 200 days and reassess the continuation of the microcosm study.

A complete time-point was conducted after approximately 190 days of incubation and results are summarized in **Table 7**. **Figure 6** shows photographs of selected microcosm bottles. Significant degradation activity was observed in four of nine experimental (live treatment) groundwater control (no electron shuttle compounds added) microcosms after 190 days of incubation.  $^{14}\text{C}$ -VC loss in these four microcosms was  $82\pm3$  percent. The activity not recovered as  $^{14}\text{C}$ -VC was entirely associated with  $^{14}\text{C}$ -ethene. This indicated that reductive dechlorination of VC was the significant degradation process in these sediments in the absence of electron shuttle addition. It should be noted, however, that no significant loss of  $^{14}\text{C}$ -VC or accumulation of  $^{14}\text{C}$ -products was observed in five of the nine experimental water control microcosms. The mean  $^{14}\text{C}$ -VC loss for all nine experimental water control microcosms was  $37\pm43$  percent. No evidence of  $^{14}\text{C}$ -VC loss or accumulation of  $^{14}\text{C}$ -products was observed in autoclaved sediment control or sediment free control microcosms prepared with water only. Based on these results, it was concluded that a potential for VC biodegradation was present in Site sediments, but that the activity was low. Under these laboratory conditions, biodegradation activity was associated with reductive dechlorination to ethene.

**Table 7**  
**Microcosm Results**

Condition	VC loss	Ethene Prod.	CO <sub>2</sub> Prod.
Groundwater only control (4 out of 9 bottles showed activity)	82%	82%	0%
AQDS – high conc. (1 out of 3 bottles showed activity)	100%	0%	100%
AQDS – medium conc.	0%	0%	0%
AQDS – low conc.	0%	0%	0%
Humic acid (all conc.)	0%	0%	0%
Sulfonated humate (all conc.)	0%	0%	0%
Indigo carmine (all conc.)	0%	0%	0%



**Figure 6 Selected Microcosm Bottles. No electron shuttles (left showing replicates), Indigo Carmine (middle showing different shuttle concentrations), and Monterey Ag-Resources HA-12 (right showing different shuttle concentrations).**

No evidence of  $^{14}\text{C}$ -VC loss or accumulation of  $^{14}\text{C}$ -products was observed in experimental (live), autoclaved control or sediment free control microcosms at any shuttle concentration in those treatments prepared with Monterey humic acids, LignoTech sulfonated humic acids, or indigo carmine. This result is significant, as it suggests that addition of these electron shuttles inhibits the reduction of  $^{14}\text{C}$ -VC to  $^{14}\text{C}$ -ethene that was observed in some of the groundwater only control microcosms. This is consistent with the hypothesized oxidizing effect of the addition of oxidized electron shuttle compounds to otherwise reduced sediments. However, no evidence of biodegradation of  $^{14}\text{C}$ -VC to  $^{14}\text{CO}_2$  was observed under these shuttle amended conditions after 190 days incubation.

No evidence of  $^{14}\text{C}$ -VC loss or accumulation of  $^{14}\text{C}$ -products was observed in experimental (live) microcosms prepared with AQDS at either low or medium concentrations. Complete  $^{14}\text{C}$ -VC loss was observed in one of three experimental (live) microcosms prepared with high concentrations of AQDS. In this treatment,  $^{14}\text{C}$ -radioactivity was recovered entirely as  $^{14}\text{CO}_2$ . The mean  $\pm$  standard deviation (SD) for  $^{14}\text{C}$ -VC loss when considering all three experimental (live) microcosms in the high AQDS treatment was  $36\pm56$  percent. No evidence of  $^{14}\text{C}$ -VC loss or accumulation of  $^{14}\text{C}$ -products was observed in autoclaved or sediment free control treatments at any AQDS treatment level.

The AQDS results indicated that high concentrations of AQDS might eventually promote  $^{14}\text{C}$ -VC degradation to  $^{14}\text{CO}_2$ . The fact that  $^{14}\text{C}$ -VC biodegradation was dominated by reduction to  $^{14}\text{C}$ -ethene in the absence of AQDS addition, however, indicated that a significant reductive capacity existed in these sediments. This reductive capacity would need to be overcome before oxidative degradation of VC would be expected to become significant. If this is the case then the onset of oxidative degradation would be expected to occur first or, perhaps, only under relatively high concentrations of AQDS. The oxidation of  $^{14}\text{C}$ -VC to  $^{14}\text{CO}_2$  in one of three experimental microcosms at high AQDS concentrations is consistent with this hypothetical relationship, but does not constitute statistically significant or compelling evidence for this process.

These data indicate that the known electron shuttle was not capable of consistently promoting vinyl chloride oxidation with SSC-OTC Site soil and groundwater after 190 days. Additionally, the commercially available electron shuttle products did not promote vinyl chloride oxidation. Whether these compounds are capable of promoting this activity at other sites is unknown. Nevertheless, use of electron shuttles for promoting oxidative transformation of VC does not appear to be warranted for the Site groundwater.

## Section 4

### Conclusions

Fifteen commercially available humic/fulvic acid products were tested, shown to be capable of being microbially reduced by iron-reducing bacteria, and in turn being able to transfer these electrons to ferric citrate. The relative electron shuttling capacity of these compounds varied from 6 to 49 percent of the electron shuttling capacity for a humic acids standard. Fulvic acids had a lower electron shuttling capacity than humic acids as expected. Humic acid compounds varied with respect to adsorption to soil and had  $K_{OC}$  values that ranged from 5.8 to 120 L/kg. The product having the lowest  $K_{OC}$  was a sulfonated humic acid derivative. These compounds varied with respect to remaining in solution in groundwater – only four of fourteen products tested did not precipitate when added to site groundwater. Therefore, commercial humic acid products should always be tested with site-specific groundwater prior to use because of the potential for precipitation.

Six non-humic acid products were also tested and indigo disulfonate, also known as indigo carmine or FD&C Blue number 2 was found to be particularly effective with respect to electron shuttling. This relative electron shuttling capacity of this compound was 400 percent of the humic acid standard. The other five compounds ranged in relative electron shuttling capacity from 0 to 360 percent.

Three products were tested for their ability to promote anaerobic oxidation of radiolabeled vinyl chloride. These products included a commercial humic acid product (Monterey Ag Resources HA-12), a sulfonated humic acid (LignoTech BorreGro HA-1), and indigo disulfonate. The products were selected based on the above criteria and cost. Cost was normalized per unit of electron shuttling capacity. The normalized costs ranged from \$7 to \$420 per pound of electron shuttling compounds. The normalized costs of the three selected products were \$15, \$21, \$55 per pound of electron shuttling compounds, respectively. The least expensive products were not selected for testing because they precipitated when mixed with groundwater.

None of these three products were capable of promoting vinyl chloride oxidation to carbon dioxide or reduction to ethene in groundwater and soil from the Space and Naval Warfare Systems Old Town Campus (SSC-OTC) Site in San Diego, California. The positive control with the known electron shuttling compound AQDS was also only able to promote vinyl chloride oxidation to carbon dioxide in one of three microcosms and only at the highest concentration of AQDS. Four out of nine microcosms containing soil and groundwater only demonstrated reductive dechlorination of vinyl chloride to ethane. These data indicate that electron shuttles, whether they are known compounds that have been tested in the laboratory (i.e., AQDS) or products with demonstrated electron shuttling capacity, are not necessarily capable of promoting consistent anaerobic oxidation of vinyl chloride to carbon dioxide.

Sampling and analysis of the Altus AFB biowall was conducted; however, the project was cancelled prior to completion of any data evaluation and interpretation. Reductions in total molar chlorinated ethene concentrations were somewhat greater in along the northern flow path relative to the southern flow path (i.e., 41 versus 26 percent). Biowall samples collected from the northern flow path also had greater electron shuttling capacity and bioavailable ferric iron concentrations relative to those collected from the southern flow path. Whether these biowall characteristics caused the difference in contaminant reduction cannot be determined at this time and may warrant additional research.

Other destruction mechanisms in biowalls including biogeochemical transformation are also relevant and warrant additional research. A workshop on *in situ* biogeochemical transformation of chlorinated solvents was held in 2008 (AFCEE 2008). Based on the key issues identified in the workshop, research and demonstration needs were identified. In total, seven research and two demonstration needs were identified, with most of them focused on improving the fundamental understanding of mechanisms and processes that contribute to chlorinated solvent degradation. These research and demonstration need topics include:

- Biogeochemical mechanisms of chlorinated solvent degradation.
- Geochemical and microbiological requirements for formation of active mineral phases.
- Sampling and analysis requirements and protocols for characterization and monitoring of *in situ* biogeochemical transformation.
- Geochemical modeling for predicting the development, effectiveness, and sustainability of *in situ* biogeochemical transformation.
- Data mining, sampling, analysis, and geochemical modeling of existing sites to facilitate understanding of *in situ* biogeochemical transformation in the field.
- Methods for selection of *in situ* amendments to promote formation of biogeochemically active mineral phases.
- Applicability of *in situ* biogeochemical transformation to other contaminants.
- Demonstration of a sampling and analysis protocol for characterization and monitoring of *in situ* biogeochemical transformation in the field.
- Pilot-scale demonstrations with selected amendments that promote development of *in situ* biogeochemical transformation.

This research and development will facilitate application of *in situ* biogeochemical transformation processes and result in more cost-effective ways of mitigating the risks that are associated with inorganic and organic contamination of soil, groundwater, and sediment.

## **Section 5**

## **Acknowledgements**

This report was written and edited by Dr. Patrick Evans of CDM and Carmen Lebrón of NAVFAC's Engineering Service Center respectively. Ms. Carmen Lebrón of NAVFAC ESC was the Project Manager. Funding from the Department of Defense Environmental Security Technology Certification Program (ESTCP) is gratefully acknowledged and appreciated. The support of Mr. Alan Vancil at SSC-OTC is also appreciated. Ms. Kelly Nevin conducted electron shuttle assays in the laboratory of Dr. Derek Lovley. Drs. Paul Bradley and Frank Chapelle of the U.S. Geological Survey conducted the radiolabeled vinyl chloride microcosm study. Parsons conducted sampling and analysis at Altus AFB.

## Section 6

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# **Appendix A**

## **Electron Shuttle Toxicology**

# Appendix A

## Electron Shuttle Toxicology

Electron shuttles are chemicals that assist in electron transfer from recalcitrant environmental chemicals to electron acceptors. They can be used to encourage the oxidation of chemicals such as vinyl chloride as part of subsurface bioremediation efforts. Since these chemicals must be released into the subsurface and could migrate to and with groundwater, they may, in theory, represent a potential environmental hazard. This white paper discusses the toxicology of three common electron shuttles, humic acids, indigo carmine and 2,6-anthraquinone disulfonic acid (AQDS). The discussions are intended to provide insight into the hazards, if any, that release of these chemicals during remediation may represent.

### *Humic Acids*

The following assessment of toxicology of humic acids was produced using information obtained from a number of sources including the open literature, regulatory evaluations, toxicity test reports and others. The information retrieved is not exhaustive, but should be representative of the types of studies available and the basic toxicity of humic acids.

Humic acids are a group of polymeric polyhydroxy acids that occur naturally as degradation products of plant materials. They occur in most surface waters, including rivers and streams, ponds and lakes and estuaries and oceans. Humic acids vary depending on source and their chemical composition and structure are only generally known. They are characterized by molecular weights between 2,000 and 50,000 Daltons and solubility in weak alkali but not weak acid. Much commercially available humic acid is extracted from bituminous (brown) coal as the alkali soluble organic fraction (EPA 2000, Federal Register, July 18, Vol 65, Number 138).

Toxicity of humic acids has not been well defined in typical toxicity studies. Thus, toxicity must be addressed by considering chemical properties and toxicokinetics, limited in vitro and animal studies, and information from environmental exposures and agricultural uses.

### **Chemical Properties and Toxicokinetics**

Humic acids are characteristically high molecular weight, polar chemicals. These characteristics suggest that these acids will be very poorly absorbed from the GI tract. Studies in which humic acids were administered to rodents indicated that stools turned black after a single high dose, suggesting that much of the chemical had passed through the digestive tract. Lack of absorption following oral exposure would limit any direct toxicity of humic acids to the gastrointestinal tract. However, as discussed below, even high doses of humic acids did not appear to cause any GI distress after short-term exposures.

Humic acids may act as chelators of metals, probably through binding to acid groups, although both N and S containing groups might also be involved. Chelation could, in theory, either increase or ameliorate toxicity due to heavy metals. In several studies, as summarized below, humic acids have decreased metals toxicity. Lack of long term exposure studies, however, makes definitive conclusions difficult.

## ***In Vitro and Animal Toxicity Testing***

Toxicity information on humic acids is limited, but does suggest that significant toxicity is not expected. In single dose toxicity tests, administration of 5 g of humic acids per kilogram to rats did not cause any noticeable toxicity and necropsy after 14 days did not identify any gross anatomical changes (LignoTech USA, Inc 1996, Product Safety Laboratories 2002). Administration of this single dose did not produce any noticeable GI distress (e.g., diarrhea). Similar results were observed in studies in which animals were fed for up to 90 days (Daniel, et al. 1992). No obvious toxicity was observed and no gross pathology was reported. Acute to subchronic exposure, even at doses in the range of a few to several grams per kilogram, does not appear to produce adverse effects.

Several studies have reported a protective effect of humic acids for aquatic and terrestrial plant test organisms and for earthworms exposed to toxic metals. For example, Cu toxicity to *Zea mays* was decreased when humic acids were added to test water (Ullah and Gerzabek 1991). This effect is likely due to the ability of humic acid to chelate metals and thereby make them less bioavailable.

In vitro, humic acids can produce toxicity to cultured cells that is consistent with production of free radicals (Cheng, et al. 2003). Some similar toxicity has been reported in animals following intraperitoneal injection. Free radical production may be associated with quinones and/or semi-quinones present in humic acids, but mechanisms are not known with any certainty. This in vitro or IP toxicity may not be relevant for environmental exposures, since humic acids are unlikely to be absorbed from the GI tract to any significant extent.

Tests for mutagenicity with humic acids have been negative in almost all cases (Bernacchi, et al. 1996; Ribs, et al. 1997). The only positive results reported were explained by authors as due to residual chlorine used in an extraction process (Cozzi, et al. 1993). [An exception is discussed along with information on environmental exposures in Taiwan (see below)]. Lack of mutagenicity is consistent with lack of carcinogenicity, but in vitro tests can never be conclusive. A carcinogenic response seems unlikely, however, given the size of these molecules and their expected lack of absorption from the GI tract.

Toxicity information on humic acids is limited, especially for longer exposure durations. These chemicals are of low acute toxicity, lack mutagenicity in almost all cases, and often ameliorate toxicity to aquatic organisms due to heavy metals and some organic chemicals (Xu, et al. 1996; Goodrich, et al. 1991; Kim, et al. 1999; Florence, et al. 1992; Gundersen 1994; Fent and Looser 1995). Overall, little in

available evidence suggests that humic acids would represent a significant human health risk. However, many gaps in available toxicity information exist.

## Environmental Exposures

Humic acids are ubiquitous in surface waters and many human populations are continuously exposed to these chemicals (EPA 2000, Federal Register, July 18, Vol 65, Number 138). Several literature searches have failed, with one possible exception, to provide any indication of health problems associated with exposure to humic acids in drinking water. In some parts of the US and the world, the amount of humic acids in drinking water is substantial and one would expect significant health effects to be notable if humic acids were significantly toxic. Thus, lack of reported toxicity from continuous drinking water exposures does provide some indication that exposure to humic acids does not produce chronic toxicity. Of course, this conclusion cannot be made with certainty since it is at least theoretically possible that some more subtle and/or common health effects could go unnoticed. For example, chelation of metals by humic acids could alter human responses to intake by making them either more or less bioavailable. Such effects might be less likely to be identified without actual epidemiological studies.

Humic acids have been suggested by some authors as a factor in the etiology of Blackfoot disease in Taiwan (Lu, et al. 1988). Areas where Blackfoot is endemic are characterized by high levels of arsenic and humic acids in drinking water. Since Blackfoot disease is not characteristic of all areas where arsenic levels in drinking water are elevated, factors other than arsenic exposure has been considered as factors in the development of the disease in Taiwan. Besides being found in high concentrations in drinking water, humic acids in Blackfoot areas have been shown to be mutagenic in short-term assays. The basis for this mutagenicity is not known and is inconsistent with lack of mutagenic response observed for humic acids from other sources. Further, a causal association between humic acids concentrations and Blackfoot disease does not address the issue of the size and associated lack of GI absorption of these chemicals. Some unusual aspect of humic acids from the Blackfoot disease area, or some site-related chemical associated with these acids may well be responsible for the mutagenicity and, perhaps, may be a factor in disease etiology. In any event, the association of disease with humic acids in drinking water appears to be specific for the Blackfoot disease region of Taiwan, and is likely not relevant to toxicity of humic acids in general.

## Agricultural Use

Humic acids have been used for decades as soil amendments and adjuvants for pesticide formulations for various food crops. Manufacturers, users and field workers have not reported adverse health effects of humic acids extracted, packaged and applied to fields. Moreover, EPA found that "humic acid, sodium salt is expected to be practically non-toxic to mammals" and that "a cumulative risk assessment is not necessary" to support an exception tolerance for pesticide formulations (EPA 2000, Federal Register, July 18, Vol 65, Number 138). Further, materials safety data sheets

for humic acids list few if any toxicity concerns, report no important toxic constituents or trace contaminants, and suggest few if any cautions for clean-up of spilled material (Ligno-Tech, 2004). Very wide-spread use of humic acids as soil amendments without report of any toxicity is consistent with low toxicity. Since agricultural use would go on for a number of years, agricultural use provides a glimpse of potential for human toxicity (or lack thereof) after chronic exposure.

## Summary

Toxicity of humic acids has not been characterized using standard test methods used for most chemicals. However, several lines of evidence suggest, overall, that humic acids are minimally toxic.

- Humic acids are large polar compounds and are unlikely to be absorbed for the GI tract.
- No acute toxicity is observed in laboratory animals even when very large doses (g/kg) are administered.
- Humic acids may reduce metal toxicity probably by chelating metals and making them less bioavailable.
- Except for humic acids from the area where Blackfoot disease is found in Taiwan, humic acids are not mutagenic in short-term bioassays.
- Humic acids are ubiquitous in the environment, and many communities which obtain water from surface resources have high amounts of humic acids in drinking water. Despite chronic exposure to relatively high concentrations, no reports are available that suggest any long term health consequences for people drinking these waters.
- Humic acids have been used for decades as soil amendments in agricultural settings. Workers handling these materials have not reported signs of toxicity that could be traced to humic acids.

By themselves, none of the above lines of evidence would serve to characterize chronic toxicity of humic acids. However, taken together the weight of evidence suggests that even relatively high chronic exposure to humic acids is not associated with any adverse health effects. Use of humic acids as electron shuttles for subsurface remediation would appear to pose a significant environmental risk.

## *Indigo Carmine*

Indigo carmine is a large (MW > 400) disulfonic acid that is used primarily as a food coloring. Synonyms include indigotine, CI Food Blue 1, CI Acid Blue 74, CI Natural blue 2, FD&C Blue No. 2 and many others. Because of its use as an additive to food, the chemical has been studied fairly extensively and some basic aspects of its toxicology are known with some confidence. Overall, indigo carmine is relatively

non-toxic and seem unlikely to represent a significant threat when released to the environment during remediation efforts. Much of the following description of the toxicity of indigo carmine is taken from a previous review (BIBRA Working Group, 1996).

## Acute Toxicity

Acute toxicity of indigo carmine is low, with rodent oral LD<sub>50</sub>s reported in the range of 2 g/kg. Probably, this low toxicity is due, at least in part, to low bioavailability in the GI tract. The chemical is large and polar and unlikely to be efficiently absorbed. Reported LD<sub>50</sub>s are 1 to 2 orders of magnitude lower when indigo carmine is administered s.c. or i.v. (Graham & Allmark 1959). Some reports do suggest poor GI absorption, but provide few details (Reports from the Scientific Committee for Food (1983)).

## Subchronic Toxicity

No clinical signs, gross lesions or histopathological changes were reported in dogs fed indigo carmine at up to 2 percent in the diet subchronically for 2 years (WHO 1975). Similar results were reported in pigs administered up to 1.3 g/kg-d for 90 days. In a special study of the major metabolite of indigo carmine, isatine-5-sulfonic acid, no gross or histopathological changes were noted in rats fed a diet that contained up to 2 percent of the chemical for 13 weeks (WHO 1975).

A final study using rats did suggest some effects on body weight and some biochemical parameters (e.g., kidney and liver functions) (Aboel-Zahab, et al. 1997). Doses were high and similar to those used in the subchronic studies cited above. The authors conclude that the changes seen were not serious effects.

## Chronic Toxicity

Two chronic bioassays have been reported for mice. In the first, a 2.5 mg/kg dose of indigo carmine was administered s.c. daily for 104. No treatment related tumors were reported. In the second, indigo carmine was added to feed at up to 1.6 percent for 80 weeks. Aside from slight anemia at feed concentrations of 0.8 and 1.6 percent, no treatment related changes were reported in biological, gross or histopathological parameters or tumor incidence (WHO 1975).

Four chronic bioassays have been reported using rats. In the two feeding studies, indigo carmine in the diet at concentrations up to 1 percent induced no treatment related biological or gross or histopathological changes and no increased tumor incidence was observed (Hanson, et al. 1966; Oettel, et al. 1965). Growth of male rats was inhibited at feed concentration of 2 and 5 percent, but even in these animals no other treatment related changes were observed.

Two other rat studies are reported, both involving injection of indigo carmine. In the first, a two percent solution of chemical was injected (route not specified) for 2 years. Total or daily doses were not provided. No treatment related changes were observed,

except for fibrosarcomas at the site of injection. In a shorter (7 month) study, daily s.c. injection of 1 ml of a 0.5 percent solution of indigo carmine produced no treatment related changes, including no tumors at the site of injection (WHO 1975).

## Reproductive Toxicity and Teratogenicity

In a study of potential reproductive effects, rats were administered up to 250 mg/kg-day of indigo carmine daily by gavage (Oettel, et al. 1965). No signs of either maternal or fetal toxicity were observed. Similar results were observed in rabbits administered the same doses of indigo carmine by gavage. Not surprisingly, studies using these same daily doses, but only during specific days during gestation, showed no signs of teratogenicity in either rats or rabbits (WHO 1975).

## Human Toxicity

The only reports of indigo carmine toxicity in humans come from episodes where patients were administered the chemical i.v. during surgery. The chemical was used as a vasography agent, but also caused a drop in blood pressure.

## Summary

Data appear to be sufficient to characterize the toxicity of indigo carmine as low for acute, subchronic and chronic exposure durations. Even very high doses (e.g., up to 1 to 2 percent in animal diets) appear to cause no observable changes as measured by common biochemical and gross or histopathology parameters. The chemical is large and is unlikely to be absorbed from the GI tract following ingestion. Its common use as a food coloring is consistent with a conclusion of low toxicity. Overall, releases of indigo carmine during remediation efforts should pose little if any environmental risk.

## 2,6-Anthraquinone disulfonic acid (AQDS)

The toxicity of AQDS has apparently not been characterized. A search of common toxicological databases (e.g., HSDB, Toxline, Toxnet, Medline) and of the internet recovered very little of any use in describing the toxicological properties of this chemical. Thus, overall, the environmental hazard that might be associated with release of this chemical remains largely unknown.

AQDS is a large (MW > 300) polar molecule. It would not be expected to be well absorbed from the GI tract following ingestion because of these properties, and considering the apparently low GI bioavailability of indigo carmine. Both AQDS and indigo carmine are large disulfonic acids and might be expected to behave similarly in the GI tract.

Unlike indigo carmine, AQDS is a planar molecule and can intercalate between bases in nucleic acids. Chemicals that can intercalate, such as the azo dyes and acridines, are effective mutagens and/or animal carcinogens. Thus, it is possible that AQDS has some mutagenic or carcinogenic potential.

The scant data available to describe the toxicity of AQDS make any conclusions about potential health threats associated with its release during remediation problematic.

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## **Appendix B**

## **Altus AFB Reports**

## **FINAL REPORT**

### **SUBSURFACE INVESTIGATION OF A MULCH BIOWALL AT LANDFILL 03, ALTUS AIR FORCE BASE, OKLAHOMA**

**In support of:**

**Environmental Security Technology Certification Program Project CU-0316:  
Enhanced Bioremediation of cis-Dichloroethene (cis-DCE) and Vinyl Chloride (VC)  
Using Electron Shuttles**

**Prepared for:**

**Naval Facilities Engineering Command  
Port Hueneme, California  
Contract No. N47408-99-C-7022**

**July 2005**

**Prepared by:**

**PARSONS  
1700 Broadway, Suite 900  
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**FINAL REPORT**  
**SUBSURFACE INVESTIGATION OF A MULCH BIOWALL AT LF03,**  
**ALTUS AIR FORCE BASE, OKLAHOMA**

**JULY 2005**

## **1.0 INTRODUCTION**

On 16 December 2004, the Navy modified Contract N47408-99-C-7022 with Parsons Infrastructure & Technology Group, Inc. (Parsons) to conduct soil and groundwater sampling at Altus Air Force Base (AFB), Oklahoma, in support of Environmental Security Technology Certification Program (ESTCP) Project CU-0316, *Enhanced Bioremediation of cis-Dichloroethene (cis-DCE) and Vinyl Chloride (VC) Using Electron Shuttles*. The overall ESTCP project objectives and scope of work, along with a site description, are provided in the work plan for ESTCP Project CU-0316, titled “*Draft Work Plan, Subsurface Investigation and Treatability Study Site 1 Alameda Point Alameda, California and Existing Mulch Biowall Altus Air Force Base Altus, Oklahoma*” (CDM, 2004).

The objective of the work described in this Final Report is to collect groundwater and soil/mulch substrate samples to evaluate the role of electron shuttles in the enhanced biodegradation of cis-1,2-dichlorethene (cis-DCE) and vinyl chloride (VC) in groundwater in the vicinity of an existing mulch biowall at Landfill 03 (LF03), Altus AFB. The biowall was constructed in June 2002 by Parsons for the Air Force Center for Environmental Excellence (AFCEE) and Altus AFB. This report summarizes the field activities for sample collection and presents the analytical results for the groundwater and soil/mulch samples collected at the Altus AFB LF03 mulch biowall site.

## **2.0 SCOPE OF WORK**

The location of the mulch biowall at LF-03 is shown on Figure 1 (attached). Sample collection was conducted over a period from 18 April 2005 to 22 April 2005 by drilling and sampling soil borings within the biowall, and by collecting groundwater samples from existing monitoring wells. Site activities included the following:

- Drilling and sampling of two soil borings within the biowall to a total depth of 25 feet below ground surface (bgs),
- Collection of three soil/mulch substrate samples from each boring,
- Abandoning the two soil borings,
- Collection of six groundwater samples from existing groundwater monitoring wells, and
- Disposal of investigation-derived waste (IDW).

Site activities are described in the following sections and are summarized in Table 1 (attached). Soil and groundwater samples were submitted for laboratory analyses as described in Section 3 and Section 4. In addition to the procedures described in this report, work were conducted in accordance with the *Work Plan for the Bark Mulch Trench Interim Corrective Action, In-Situ Anerobic Bioremediation of Contaminated Groundwater at Altus Air Force Base, Oklahoma* (Parsons, 2004).

### **3.0 DRILLING AND SOIL SAMPLING**

Prior to drilling, Parsons coordinated with Altus AFB and the local public utility locator to locate underground utilities. Two borings (SB-1 and SB-2) were advanced into the mulch biowall at LF03 using a truck mounted hollow stem auger rig. The soil borings were located adjacent to monitoring wells PES-MP-1 and PES-MP-6, shown on Figure 2 (attached). Boreholes were drilled using 4-1/4-inch inside-diameter hollow-stem augers, and soil samples were collected through the augers using standard split-spoon samplers. The location, number, and sample analytes are provided on Table 1. Soil/mulch matrix samples were sent to fixed-based laboratories and analyzed in accordance with the sampling protocol listed in Table 2 (attached).

Soil/mulch samples for electron shuttle bioassays and other analyses listed on Table 1 were collected and packaged to ensure sample integrity prior to analysis by the analytical laboratories. Immediately after extracting and opening the sampler, a portion of each sample was transferred to the appropriate sample container. Samples for electron shuttle bioassays were placed into 4-ounce glass jars, and groundwater from the adjacent monitoring well was added to saturate the sample and eliminate headspace. Samples for analysis of volatile organic compounds (VOCs) and total organic carbon (TOC) were placed into 4-ounce jars but were not saturated. The jars were then sealed with a Teflon<sup>®</sup>-lined cap, packaged in a cooler with ice, then shipped for overnight delivery to the analytical laboratory.

Each sample for analysis of bioavailable iron, total iron, sulfide, iron sulfides (FeS and FeS<sub>2</sub>) was placed into two 40-milliliter (ml) glass vials, sealed with a Teflon<sup>®</sup> septa cap, then purged with nitrogen gas to eliminate oxygen. The vials were then wrapped in bubble wrap, packaged in a cooler with dry ice, then shipped for overnight delivery to the analytical laboratory.

After each soil boring was completed and samples collected, the augers were retracted and the biowall material removed during drilling was placed back into the borehole.

### **4.0 GROUNDWATER SAMPLING**

Groundwater samples were collected from six existing monitoring wells (OU-1-04, PES-MP-01, PES-MP-02, WL019, PES-MP-06, and PES-MP-07), located along two transects oriented perpendicular to the mulch biowall. Although the work plan indicated an upgradient sample would be collected from well OU-1-05, well OU-1-04 was selected for the upgradient sample for the northern transect because a tracer test was being performed by the U.S. Environmental Protection Agency (USEPA) at OU-1-05 during the sampling event. Each transect is comprised of one upgradient well, one well placed within the mulch biowall, and one downgradient well (Figure 2).

Additional downgradient monitoring wells located along the biowall monitoring transects (PES-MP-03, PES-MP-04, PES-MP-05, PES-MP-08, PES-MP-09, and PES-MP-10) were sampled under a contract with AFCEE. To provide a more complete description of site conditions at the time of the sampling event, Parsons has included these data in the tables attached to this report.

Prior to collection of groundwater samples, each well was purged to remove stagnant water from the well and to allow its replacement by groundwater from the adjacent formation, which is more representative of actual aquifer conditions. A peristaltic pump was used to purge the monitoring wells and to collect groundwater samples. A dedicated

length of clean, disposable high-density polyethylene (HDPE) tubing was used for each well. Groundwater samples were both analyzed in the field and sent to fixed-based laboratories for analysis in accordance with the sampling protocol provided in Table 2.

## 5.0 ANALYTICAL RESULTS

Analytical results for soil/mulch and groundwater samples are provided in Appendix A, and are summarized on Tables 3 through 9. Data provided in Table 3 through Table 9 are as follows:

- Table 3 lists groundwater elevation data for April 2005.
- Table 4 is a summary of chlorinated aliphatic hydrocarbons (CAHs) detected in groundwater.
- Table 5 lists groundwater geochemical data.
- Table 6 lists concentrations of total organic carbon and volatile fatty acids in groundwater.
- Table 7 lists concentrations of dissolved metals (arsenic, selenium, and manganese) in groundwater for select wells (OU1-04, WL-019, PES-MP2, and PES-MP7).
- Table 8 is a summary of analytical results for CAHs in samples of the sand/mulch mixture from the biowall.
- Table 9 is a summary of the shuttling capacity of soil/mulch samples determined by bioassays conducted at the University of Massachusetts.
- Table 10 is a summary of the soil mineralogical analyses of the soil mulch mixtures.

## 6.0 INVESTIGATION-DERIVED WASTE

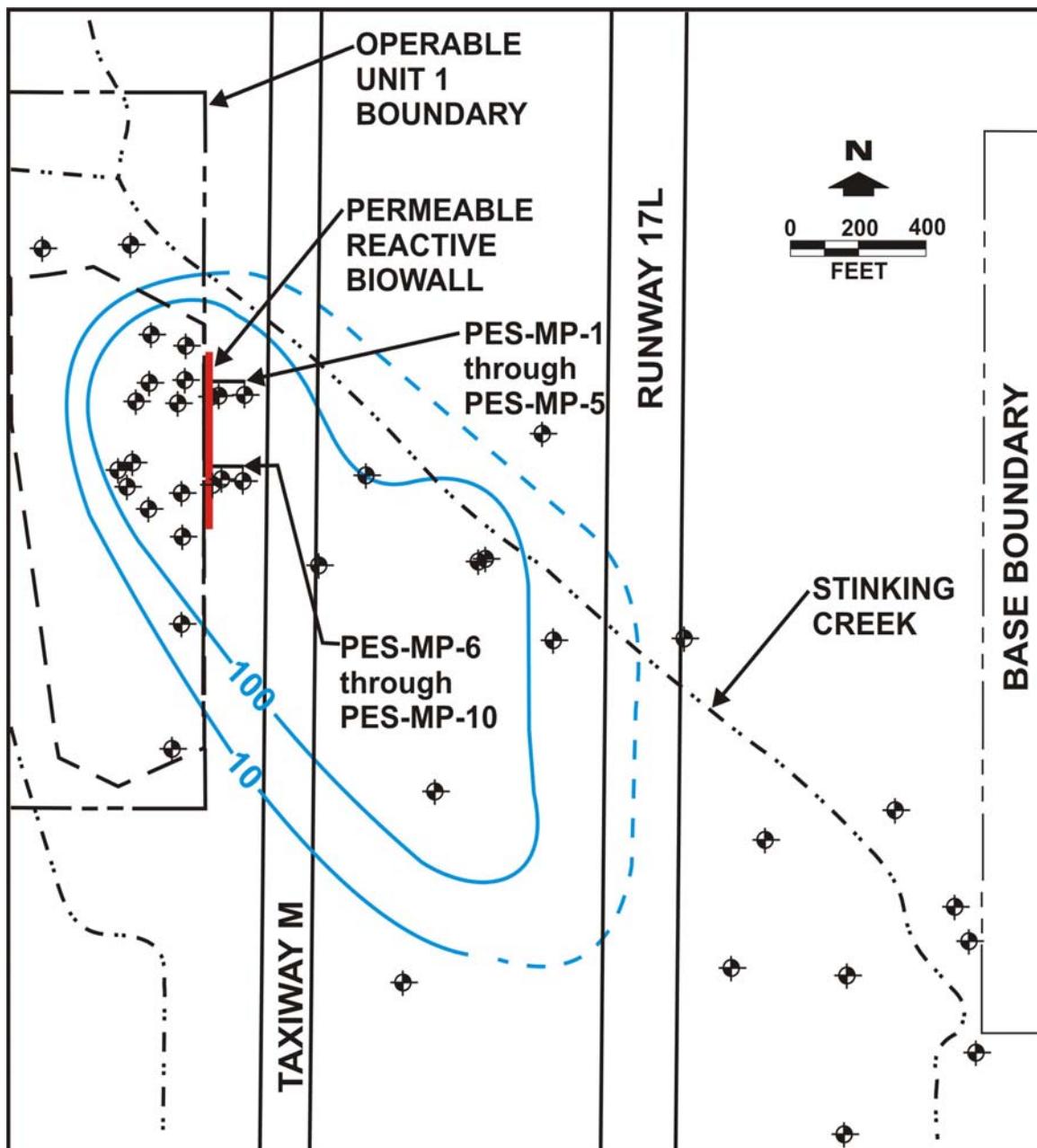
Solid IDW waste such as personal protective equipment (PPE), disposable sample tubing, disposable gloves, etc. were double-bagged and disposed to the Base solid waste handling system. Liquid IDW and decontamination fluids generated at the site were containerized and discharged to the Base groundwater treatment system. Drill cuttings were used to backfill the soil borings immediately following soil/mulch sampling activities.

## 7.0 REFERENCES

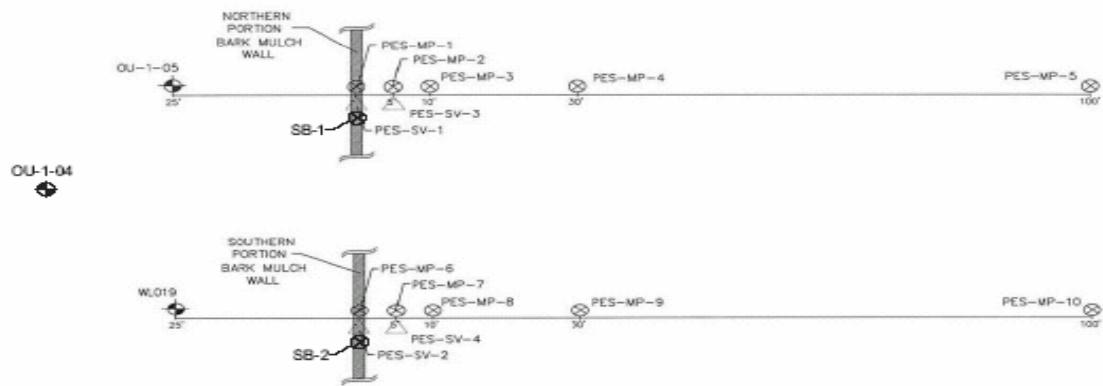
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## **FIGURES**



**Figure 1. Location of Mulch Biowall Relative to TCE Plume (isoconcentration contours in micrograms per liter of TCE in April 1999. (CDM, 2004)**



**Figure 2. Monitoring Well Sampling Locations Relative to Mulch Biowall. (CDM, 2004)**

## **TABLES**

**TABLE 1**  
**SUMMARY OF PROPOSED SAMPLING ACTIVITIES**  
**BIOWALL SAMPLING AND ANALYSIS PLAN**  
**ALTUS AFB, OKLAHOMA**

Location Identifier	Requires Drilling Installation	Location Description	Soil/Mulch Analyses								Groundwater Analyses							
			VOCs <sup>a</sup> (SW8260B)	Total Organic Carbon (SW9060mod)	Total Iron, Sulfide, FeS, and FeS <sub>2</sub> (Microseeps SOP) <sup>b</sup>	Bioavailable Iron (New Horizons)	Electron Shuttle Bioassay (UMASS) <sup>c</sup>	8 RCRA Metals (SW6010B)	VOCs (SW8260B)	Methane, Ethane, Ethene (AM-20GAX)	Nitrate + Nitrite (E353.1)	Sulfate (E300.1)	Chloride (E300.1)	Total Organic Carbon (SW9060M)	Volatile Fatty Acids (Microseeps SOP)	Total Dissolved Solids (E160.3)	Hardness (E130.2)	Well Head Analyses <sup>d</sup>
<b>Soil Boreholes</b>																		
SB-1	X	Within Biowall	3	3	3	3	3											
SB-2	X	Within Biowall	3	3	3	3	3											
<b>Groundwater Monitoring Wells</b>																		
OU1-1		20' Upgradient of Biowall							1	1	1	1	1	1	1	1	1	1
PES-MP01		Within Biowall							1	1	1	1	1	1	1	1	1	1
PES-MP02		5' Downgradient of Biowall							1	1	1	1	1	1	1	1	1	1
WL-019		20' Upgradient of Biowall							1	1	1	1	1	1	1	1	1	1
PES-MP06		Within Biowall							1	1	1	1	1	1	1	1	1	1
PES-MP07		5' Downgradient of Biowall							1	1	1	1	1	1	1	1	1	1
<b>SUBTOTALS</b>			6	6	6	6	6		6	6	6	6	6	6	6	6	6	6
<b>Quality Assurance/Quality Control (QA/QC)</b>																		
Duplicates			1	1	1	1	1		1	1	1	1	1	1	1	1	1	1
Matrix Spike			1						1									
Matrix Spike Duplicate			1						1									
Trip Blanks									1									
<b>Investigation-Derived Waste (IDW) Characterization</b>																		
Soil IDW			1						1									
<b>TOTALS</b>			10	7	7	7	7	7	1	10	7	7	7	7	7	7	7	7

<sup>a</sup> Volatile organic compounds (VOCs) to include aromatic and chlorinated aliphatic hydrocarbons.

<sup>b</sup> Microseeps analytical laboratory internal standard operating procedure (SOP).

<sup>c</sup> University of Massachusetts analytical laboratory internal SOP.

<sup>d</sup> Well head analyses include dissolved oxygen, oxidation-reduction potential, pH, temperature, and conductivity.

<sup>e</sup> Mobile lab analyses include carbon dioxide, alkalinity, ferrous iron, hydrogen sulfide, and manganese.

**TABLE 2**  
**ANALYTICAL PROTOCOLS FOR GROUNDWATER,**  
**SOIL, AND MULCH/SAND SAMPLES**  
**LF03 MULCH BIOWALL**  
**ALTUS AFB BIOWALL, OKLAHOMA**

<b>MATRIX</b>		<b>FIELD (F) OR ANALYTICAL LABORATORY (L)</b>
<b>ANALYTE</b>	<b>METHOD</b>	
<b>WATER</b>		
Redox Potential	Direct-reading meter	F
Dissolved Oxygen	Direct-reading meter	F
pH	Direct-reading meter	F
Specific Conductance	Direct-reading meter	F
Temperature	Direct-reading meter	F
Ferrous Iron	Colorimetric, Hach Method 8146 (or similar)	F
Manganese	Colorimetric, Hach Method 8034 (or similar)	F
Alkalinity (Carbonate $\text{CO}_3^{2-}$ )	Titrimetric, Hach Method 8221 (or similar)	F
Hydrogen Sulfide	Colorimetric, Hach Method 8131 or HS-C	F
Carbon Dioxide	Titrimetric, CHEMetrics Method 4500 (or similar)	F
Nitrate + Nitrite [as Nitrogen (N)]	E300.1	L
Sulfate	E300.1	L
Chloride	E300.1	L
Methane, Ethane, Ethene	AM-20GAX <sup>a/</sup>	L
Total Organic Carbon	SW9060	L
VOCs <sup>b/</sup>	SW8260B	L
Volatile Fatty Acids	Microbial Insights SOP	L
Total Dissolved Solids	E160.3	L
Hardness	E130.2	L
<b>MULCH/SAND</b>		
VOCs <sup>b/</sup>	SW8260B	L
Total Organic Carbon	Walkley Black modified	L
Bioavailable Iron	New Horizons Test Kit	L
Total Iron, Sulfide, FeS, and FeS <sub>2</sub>	AMIBA Protocol (Rowan University SOP)	L
Electron Shuttles Bioassays	University of Massachusetts	L
RCRA 8 Metals	SW6010B	L

<sup>a/</sup> AM-20GAX = Microseeps, Inc. laboratory standard operating procedure.

<sup>b/</sup> VOCs = volatile organic compounds.

**TABLE 3**  
**SUMMARY OF GROUNDWATER ELEVATIONS**  
**LF03 MULCH BIOWALL**  
**ALTUS AFB, OKLAHOMA**

Well/Borehole Identification	Date	Screened Interval (feet bgs) <sup>a/</sup>	Northing	Easting	Ground Surface (feet amsl) <sup>b/</sup>	Elevation Datum (feet amsl)	Depth to Water (feet btoc) <sup>c/</sup>	Groundwater Elevation (feet amsl)
<b>Northern Flow Path</b>								
OU1-04	19-Apr-05	6 - 24	486745.3400	1588393.4400	1352.2	1354.51	8.03	1346.48
PES-MP01	19-Apr-05	14 - 24	486772.2111	1588421.6229	1351.2	1351.11	4.69	1346.42
PES-MP02	19-Apr-05	14 - 24	486771.4853	1588426.3728	1351.7	1351.12	4.98	1346.14
PES-MP03	19-Apr-05	14 - 24	486770.8773	1588432.0179	1351.4	1351.34	5.43	1345.91
PES-MP04	19-Apr-05	14 - 24	486769.8790	1588450.7908	1352.4	1352.03	5.96	1346.07
PES-MP05	20-Apr-05	14 - 24	486765.5955	1588521.4885	1357.5	1357.25	11.22	1346.03
<b>Southern Flow Path</b>								
WL019	18-Apr-05	6 - 20	14636.8300	16663.9500	1354.1	1356.62	10.69	1345.93
PES-MP06	18-Apr-05	14 - 24	486529.9470	1588418.4631	1353.1	1352.66	6.78	1345.88
PES-MP07	18-Apr-05	14 - 24	486530.9113	1588423.4346	1353.0	1352.61	6.73	1345.88
PES-MP08	20-Apr-05	14 - 24	486530.6773	1588428.6648	1352.8	1352.35	5.48	1346.87
PES-MP09	20-Apr-05	14 - 24	486532.7401	1588447.4666	1353.0	1352.69	6.54	1346.15
PES-MP10	20-Apr-05	14 - 24	486539.1280	1588518.1083	1356.6	1356.38	10.39	1345.99

<sup>a/</sup> feet bgs indicates feet below ground surface.

<sup>b/</sup> feet amsl indicates elevation in feet above mean sea level.

<sup>c/</sup> feet btoc indicates depth in feet below top of casing.

**TABLE 4**  
**SUMMARY OF CHLORINATED ALIPHATIC HYDROCARBONS DETECTED IN GROUNDWATER**  
**LF03 MULCH BIOWALL**  
**ALTUS AFB, OKLAHOMA**

Sample Identification	Sampling Location	Sample Date	Dilution	PCE <sup>a/</sup> ( $\mu\text{g/L}$ ) <sup>b/</sup>	TCE <sup>a/</sup> ( $\mu\text{g/L}$ )	1,1-DCE <sup>a/</sup> ( $\mu\text{g/L}$ )	<i>cis</i> -1,2-DCE ( $\mu\text{g/L}$ )	<i>trans</i> -1,2-DCE ( $\mu\text{g/L}$ )	VC <sup>a/</sup> ( $\mu\text{g/L}$ )	Methylene Chloride ( $\mu\text{g/L}$ )
<b>Northern Flow Path</b>										
OU1-04	Upgradient	19-Apr-05	100	<50 <sup>c/</sup>	1,500	<50	550	64	<100	23J <sup>d/</sup>
PES-MP01 (0')	Within Biowall	19-Apr-05	25	<12	<12	<12	69	5.5J	590	5.9J
PES-MP11 (duplicate)	Within Biowall	19-Apr-05	20	<10	<10	<10	89	5.6J	610	<40
PES-MP02 (5')	5' Downgradient	19-Apr-05	25	<12	<12	<12	300	11J	380	3.5J
PES-MP03 (10')	10' Downgradient	19-Apr-05	50	<50	10.1J	<50	2,095	31	259	5.79J
PES-MP04 (30')	30' Downgradient	19-Apr-05	50/100	<50	174	<50	1,170	71	120	<50
PES-MP05 (100')	100' Downgradient	20-Apr-05	100	<100	581	<100	2,461	76.5J	<100	18.9J
<b>Southern Flow Path</b>										
WL019	Upgradient	18-Apr-05	2.5	<1.2	74	0.46J	73	16	<2.5	<5.0
PES-MP06 (0')	Within Biowall	18-Apr-05	5	<2.5	5.8	<2.5	85	24	3.0J	<10
PES-MP07 (5')	5' Downgradient	18-Apr-05	10	<5.0	<5.0	<5.0	190	28	4.6J	<20
PES-MP08 (10')	10' Downgradient	20-Apr-05	10	<10	3.32J	<10	272	32	5.39J	<20
PES-MP18 (duplicate)	10' Downgradient	20-Apr-05	10	<10	3.24J	<10	275	31.82	5.58J	<20
PES-MP09 (30')	30' Downgradient	20-Apr-05	20	<20	7.67J	<20	314	80	3.65J	<40
PES-MP10 (100')	100' Downgradient	20-Apr-05	20	<20	407	<20	79	26	<20	<40

<sup>a/</sup> PCE = tetrachloroethene, TCE = trichloroethene, DCE = dichloroethene, VC = vinyl chloride.

<sup>b/</sup>  $\mu\text{g/L}$  = micrograms per liter.

<sup>c/</sup> <50 indicates the concentration is below the practical quantification limit indicated.

<sup>d/</sup> J-flag indicates the concentration is below the quantification limit but above the method detection limit, and the concentration is estimated.

**TABLE 5**  
**GROUNDWATER GEOCHEMICAL DATA**  
**LF03 MULCH BIOWALL**  
**ALTUS AFB, OKLAHOMA**

Sample Location (feet from trench)	Sample Date	Temp (°C) <sup>a/</sup>	pH (su) <sup>b/</sup>	Conductivity (mS/cm) <sup>c/</sup>	Dissolved Oxygen (mg/L) <sup>d/</sup>	Redox Potential (mV) <sup>e/</sup>	Dissolved Organic Carbon (mg/L)	Nitrate- Nitrite (as N) (mg/L)	Manganese (mg/L)	Ferrous Iron (mg/L)	Hydrogen Sulfide (mg/L)	Carbon Chloride (mg/L)	Dioxide Alkalinity (mg/L)	Methane (µg/L) <sup>f/</sup>	Ethane (µg/L)	Ethene (µg/L)		
<b>Northern Flow Path</b>																		
OU-1-04	19-Apr-05	17.1	6.75	3.47	8.20	-90	12.0	0.24	0.9	0.16	1,600	0.25	250	148	308	13	0.055	0.071
PES-MP01 (0')	19-Apr-05	16.0	6.23	4.02	0.60	-332	79	0.020J <sup>g/</sup>	21.2	0.14	190	0.16	330	928	1,512	12,000	0.006	3.3
PES-MP11 (Duplicate)	19-Apr-05	16.0	6.23	4.02	0.60	-332	320	0.033J	NA <sup>h/</sup>	NA	180	NA	350	NA	NA	11,000	<0.005	3.0
PES-MP02 (5')	19-Apr-05	17.4	6.30	5.07	0.40	-340	100	<0.050	22.0	0.07	930	0.72	290	1,160	1,780	14,000	0.005	1.6
PES-MP03 (10')	19-Apr-05	17.0	6.36	5.05	0.60	-206	36	<0.050	5.5	1.0	1,100	0.23	250	688	984	14,000	<0.005	0.800
PES-MP04 (30')	19-Apr-05	16.2	6.35	5.53	0.50	-188	28	0.028J	9.0	1.4	1,300	0.05	270	452	836	8,200	<0.005	0.410
PES-MP05 (100')	20-Apr-05	17.0	6.57	3.49	0.50	25	10.0	0.24	0.80	0.11	1,100	<0.10	300	304	560	1,700	<0.005	0.071
<b>Southern Flow Path</b>																		
WL019	18-Apr-05	16.8	6.72	4.21	0.60	94	10	0.019J	2.2	0.04	1,900	0.025	340	160	394	20	0.032	0.036
PES-MP06 (0')	18-Apr-05	18.4	6.34	4.08	0.60	-315	25	0.038J	12.8	0.04	2200	0.10	380	492	685	13,000	<0.005	0.27
PES-MP07 (5')	18-Apr-05	16.6	6.45	4.85	0.40	-152	51	<0.050	6.5	2.1	1,300	0.22	370	1,143	1,492	13,000	0.031	0.340
PES-MP08 (10')	20-Apr-05	16.9	6.37	4.48	0.4	-159	57	<0.050	8.2	1.7	1,600	0.03	330	1,034	1,360	13,000	<0.005	0.180
PES-MP09 (30')	20-Apr-05	17.3	6.39	3.82	0.40	-22	26	<0.050	NA	NA	1,100	NA	330	NA	NA	1,800	<0.005	0.087
PES-MP10 (100')	20-Apr-05	18.5	6.71	4.42	1.00	61	10	0.58	17.8	<0.2	3,200	<0.10	410	150	292	12	0.010	0.014

<sup>a/</sup> °C = degrees Centigrade.

<sup>e/</sup> mV = millivolts.

<sup>b/</sup> su = standard pH units.

<sup>f/</sup> µg/L = micrograms per liter.

<sup>c/</sup> mS/cm = millisiemens per centimeter.

<sup>g/</sup> J-flag indicates the concentration is below the quantification limit but above the method detection limit, and the concentration is estimated.

<sup>d/</sup> mg/L = milligrams per liter.

<sup>h/</sup> NA = not analyzed.

**TABLE 6**  
**TOTAL ORGANIC CARBON AND VOLATILE FATTY ACIDS IN GROUNDWATER**  
**LF03 MULCH BIOWALL**  
**ALTUS AFB, OKLAHOMA**

Sample Location	Sample Date	Total Organic Carbon (mg/L) <sup>a/</sup>	Total VFAs (mg/L)	Volatile Fatty (Metabolic) Acids								
				Pyruvic (mg/L)	Lactic (mg/L)	Formic (mg/L)	Acetic (mg/L)	Propionic (mg/L)	Butyric (mg/L)			
<b>MONITORING WELLS</b>												
<b>Northern Flow Path</b>												
OU-1-04	19-Apr-05	12	ND <sup>b/</sup>	<4 <sup>c/</sup>	<1	<1	<1	<1	<1			
PES-MP01	19-Apr-05	79	ND	<4	<1	<1	<1	<1	<1			
PES-MP11 (Dup)	19-Apr-05	320	ND	<4	<1	<1	<1	<1	<1			
PES-MP02	19-Apr-05	100	ND	<4	<1	<1	<1	<1	<1			
PES-MP03	19-Apr-05	36	ND	<4	<1	<1	<1	<1	<1			
PES-MP04	19-Apr-05	28	ND	<4	<1	<1	<1	<1	<1			
PES-MP05	20-Apr-05	10	ND	<4	<1	<1	<1	<1	<1			
<b>Southern Flow Path</b>												
WL019	18-Apr-05	10	ND	<4	<1	<1	<1	<1	<1			
PES-MP06	18-Apr-05	25	ND	<4	<1	<1	<1	<1	<1			
PES-MP07	18-Apr-05	51	ND	<4	<1	<1	<1	<1	<1			
PES-MP08	20-Apr-05	57	ND	<4	<1	<1	<1	<1	<1			
PES-MP09	20-Apr-05	26	ND	<4	<1	<1	<1	<1	<1			
PES-MP10	20-Apr-05	10	ND	<4	<1	<1	<1	<1	<1			

<sup>a/</sup> mg/L = milligrams per liter.

<sup>b/</sup> ND = not detected.

<sup>c/</sup> "<" indicates that the analyte was below the limit of quantitation.

**TABLE 7**  
**DISSOLVED METALS IN GROUNDWATER**  
**LF03 MULCH BIOWALL**  
**ALTUS AFB, OKLAHOMA**

Sample Identification	Location	Sample Date	Arsenic (mg/L) <sup>a/</sup>	Selenium (mg/L)	Manganese (mg/L)
OU1-04	Upgradient of Biowall	19-Apr-05	<0.01 <sup>b/</sup>	0.015J <sup>c/</sup>	0.22
WL-019	Upgradient of Biowall	18-Apr-05	<0.01	0.011J	0.37
PES-MP2	5 Feet Downgradient of Biowall	19-Apr-05	0.03	0.013J	1.5
PES-MP7	5 Feet Downgradient of Biowall	18-Apr-05	<0.01	0.016J	1.3

<sup>a/</sup> mg/L = milligrams per liter.

<sup>b/</sup> "<" indicates that the analyte was below the limit of quantitation.

<sup>c/</sup> J-flag indicates the concentration is below the quantification limit but above the method detection limit, and the concentration is estimated.

**TABLE 8**  
**SUMMARY OF ANALYTICAL RESULTS FOR MULCH MIXTURE**  
**LF03 MULCH BIOWALL**  
**ALTUS AFB, OKLAHOMA**

Sample Location	Sample Date	Sample Depth (feet bgs) <sup>a/</sup>	Moisture (percent)	TCE <sup>b/</sup> (µg/kg) <sup>c/</sup>	<i>cis</i> -1,2-DCE <sup>b/</sup> (µg/kg)	<i>trans</i> - 1,2-DCE (µg/kg)	VC <sup>b/</sup> (µg/kg)	Methylene Chloride (µg/kg)	Benzene (µg/kg)	Toluene (µg/kg)	p-Isopropyl-toluene (µg/kg)	2-butanone (µg/kg)	Acetone (µg/kg)
<b>Biowall Samples</b>													
SB1-5	22-Apr-05	5	32.2%	<3.6 <sup>d/</sup>	43	0.90J <sup>e/</sup>	<7.2	<7.2	<3.6	16	0.89J	42	120B <sup>f/</sup>
SB1-15	22-Apr-05	15	38.2%	12	440	17	130	1.1J	<4.0	8.8	54	56	160B
SB1-20	22-Apr-05	20	45.1%	25	760	18	210	<8.3	<4.1	11	49	17	73B
SB2-7	22-Apr-05	7	21.5%	<3.1	3.0J	<3.1	<6.1	0.66J	<3.1	22	0.64J	37	130B
SB12-7 (duplicate)	22-Apr-05	7	35.4%	<3.7	9.2	1.7J	<7.5	0.89J	0.81J	40	2.7J	33	110B
SB2-15	22-Apr-05	15	29.0%	1.5J	330	20	1.4J	<6.8	<3.4	36	260	48	120B
SB2-20	22-Apr-05	20	19.9%	<3.1	130	6.7	<6.1	0.65J	<3.1	8.6	92	54	160B

<sup>a/</sup> feet bgs = feet below ground surface.

<sup>b/</sup> TCE = trichloroethene; DCE = dichloroethene; VC = vinyl chloride.

<sup>c/</sup> µg/kg = micrograms per kilogram.

<sup>d/</sup> <3.6 indicates that the analyte was not detected above the indicated method detection limit.

<sup>e/</sup> J flag indicates that the analyte was detected at a concentration above the method detection limit but below the reporting limit resulting in an estimated value.

<sup>f/</sup> B flag indicates that the analyte was detected in the sample blank.

**TABLE 9**  
**HUMICS IN SOIL**  
**LF03 MULCH BIOWALL**  
**ALTUS AFB, OKLAHOMA**

Sample Identification (Borehole ID-sample depth)	Sample Date	Test Concentration (Dry Weight) (g/L) <sup>a/</sup>	Shutting Capacity (% of 0.5 g/L IHSS Soil Humic Acid standard)	Shutting Capacity 0.2475 mM Fe Reduced (Average of duplicates)
SB1-5	22-Apr-05	1.0	78.79	0.195
SB1-15	22-Apr-05	1.0	63.03	0.156
SB1-20	22-Apr-05	1.0	46.67	0.1155
SB2-7	22-Apr-05	1.0	29.70	0.0735
SB12-7 (Duplicate)	22-Apr-05	1.0	0	0
SB2-15	22-Apr-05	1.0	32.73	0.081
SB2-20	22-Apr-05	1.0	0	0

<sup>a/</sup> g/L = gram per liter.

**TABLE 10**  
**SUMMARY OF SOIL/MULCH MINERALOGICAL RESULTS**  
**LF03 MULCH BIOWALL**  
**ALTUS AFB, OKLAHOMA**

Sample Location	Sample Date	Sample Depth (feet bgs) <sup>a/</sup>	Percent Solids	Organic Carbon (mg/kg) <sup>b/</sup>	WAEFe <sup>3+</sup> <sup>c/</sup> (mg/kg)	SAEFe <sup>3+</sup> <sup>c/</sup> (mg/kg)	WAEFe <sup>2+</sup> <sup>c/</sup> (mg/kg)	SAEFe <sup>2+</sup> <sup>c/</sup> (mg/kg)	WAEMn <sup>c/</sup> (mg/kg)	SAEMn <sup>c/</sup> (mg/kg)	AVS <sup>c/</sup> (mg/kg)	CES <sup>b/</sup> (mg/kg)
SB1-5	22-Apr-05	5	60%	29,000	<200 <sup>d/</sup>	<300	1,300	3,700	<200	<300	13,000	19,000
SB1-15	22-Apr-05	15	63%	41,000	<200	<300	1,900	5,200	<200	<300	13,000	9,800
SB1-20	22-Apr-05	20	64%	21,000	<200	<300	<200	500	<200	<300	6,900	7,800
SB2-7	22-Apr-05	7	86%	15,000	<100	<200	300	1,000	<100	<200	9,000	6,400
SB12-7 (duplicate)	22-Apr-05	7	67%	23,000	<100	400	600	1,800	<100	<300	14,000	12,000
SB2-15	22-Apr-05	15	78%	18,000	<100	<200	1,200	3,100	<100	<200	9,400	2,400
SB2-20	22-Apr-05	20	78%	20,000	<100	900	3,100	5,400	<100	<200	7,400	8,200

<sup>a/</sup> feet bgs = feet below ground surface.

<sup>b/</sup> mg/kg = micrograms per kilogram dry weight.

<sup>c/</sup> WAEFe<sup>3+</sup> = weak acid extractable ferric iron; SAEFe<sup>3+</sup> = strong acid extractable ferric iron; WAEFe<sup>2+</sup> = weak acid extractable ferrous iron;

SAEFe<sup>2+</sup> = strong acid extractable ferrous iron; WAEMn = weak acid divalent manganese; SAEMn = strong acid extractable divalent manganese;

AVS = acid volatile sulfide; CES = chromium extractable sulfide.

<sup>d/</sup> <200 indicates that the analyte was not detected above the indicated method detection limit.

**APPENDIX A**  
**ANALYTICAL RESULTS**

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4054  
Sample Description: OUI-04  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/19/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042805W1  
Prepared: 04/28/05 %Solids:  
Sample Size: 10 mL  
Dilution: 100

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
Dichlorodifluoromethane	<100.	U	3.0	100.	04/28/05
Chloromethane	<100.	U	3.4	100.	04/28/05
Vinyl chloride	<100.	U	3.1	100.	04/28/05
Bromomethane	<100.	U	9.7	100.	04/28/05
Chloroethane	<100.	U	8.3	100.	04/28/05
Trichlorofluoromethane	<100.	U	1.8	100.	04/28/05
Acetone	<1000.	U	23.	1000.	04/28/05
1,1-Dichloroethene	<50.	U	2.2	50.	04/28/05
Methylene chloride	J 23.	J	8.9	200.	04/28/05
trans-1,2-Dichloroethene	64.		3.9	50.	04/28/05
Methyl tert-butyl ether	<50.	U	3.2	50.	04/28/05
1,1-Dichloroethane	<50.	U	2.2	50.	04/28/05
2-Butanone	<1000.	U	68.	1000.	04/28/05
cis-1,2-Dichloroethene	550.		3.9	50.	04/28/05
Bromochloromethane	<50.	U	7.4	50.	04/28/05
Chloroform	<50.	U	2.3	50.	04/28/05
2,2-Dichloropropane	<50.	U	2.9	50.	04/28/05
1,2-Dichloroethane	<50.	U	1.8	50.	04/28/05
1,1,1-Trichloroethane	<50.	U	4.1	50.	04/28/05
1,1-Dichloropropene	<50.	U	2.6	50.	04/28/05
Carbon tetrachloride	<50.	U	3.3	50.	04/28/05
Benzene	<50.	U	1.7	50.	04/28/05
Dibromomethane	<50.	U	2.5	50.	04/28/05
1,2-Dichloropropane	<50.	U	4.7	50.	04/28/05
Trichloroethene	1500.		3.1	50.	04/28/05
Bromodichloromethane	<50.	U	2.3	50.	04/28/05
cis-1,3-Dichloropropene	<50.	U	2.6	50.	04/28/05
4-Methyl-2-pentanone	<500.	U	120.	500.	04/28/05
trans-1,3-Dichloropropene	<50.	U	3.1	50.	04/28/05
1,1,2-Trichloroethane	<50.	U	4.3	50.	04/28/05
Toluene	<50.	U	1.6	50.	04/28/05
1,3-Dichloropropane	<50.	U	2.8	50.	04/28/05
Dibromochloromethane	<50.	U	1.7	50.	04/28/05

B - Analyte detected above the PQL in the associated Prep Blank.

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J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

Authorized: Monika Santucci  
Date: May 3, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4054  
Sample Description: OUI-04  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/19/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042805W1  
Prepared: 04/28/05 %Solids:  
Sample Size: 10 mL  
Dilution: 100

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
1,2-Dibromoethane	<50.	U	3.2	50.	04/28/05
Tetrachloroethene	<50.	U	4.6	50.	04/28/05
1,1,1,2-Tetrachloroethane	<50.	U	5.3	50.	04/28/05
Chlorobenzene	<50.	U	1.7	50.	04/28/05
1-Chlorohexane	<50.	U	5.4	50.	04/28/05
Ethylbenzene	<50.	U	2.5	50.	04/28/05
Bromoform	<50.	U	13.	50.	04/28/05
Xylene (total)	<50.	U	4.1	50.	04/28/05
Styrene	<50.	U	1.7	50.	04/28/05
1,1,2,2-Tetrachloroethane	<50.	U	4.6	50.	04/28/05
1,2,3-Trichloropropane	<50.	U	36.	50.	04/28/05
Isopropylbenzene	<50.	U	1.5	50.	04/28/05
Bromobenzene	<50.	U	2.4	50.	04/28/05
n-Propylbenzene	<50.	U	1.2	50.	04/28/05
2-Chlorotoluene	<50.	U	2.8	50.	04/28/05
4-Chlorotoluene	<50.	U	1.4	50.	04/28/05
1,3,5-Trimethylbenzene	<50.	U	3.2	50.	04/28/05
tert-Butylbenzene	<50.	U	1.7	50.	04/28/05
n-Butylbenzene	<50.	U	4.8	50.	04/28/05
1,2,4-Trimethylbenzene	<50.	U	2.4	50.	04/28/05
sec-Butylbenzene	<50.	U	1.9	50.	04/28/05
1,3-Dichlorobenzene	<50.	U	2.1	50.	04/28/05
1,4-Dichlorobenzene	<50.	U	3.9	50.	04/28/05
p-Isopropyltoluene	<50.	U	2.2	50.	04/28/05
1,2-Dichlorobenzene	<50.	U	6.7	50.	04/28/05
1,2-Dibromo-3-chloropropane	<100.	U	22.	100.	04/28/05
1,2,4-Trichlorobenzene	<100.	U	13.	100.	04/28/05
Naphthalene	<100.	U	13.	100.	04/28/05
Hexachlorobutadiene	<100.	U	15.	100.	04/28/05
1,2,3-Trichlorobenzene	<100.	U	14.	100.	04/28/05

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Authorized: *Monika Santucci*  
Date: May 3, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4054  
Sample Description: OUI-04  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/19/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042805W1  
Prepared: 04/28/05 %Solids:  
Sample Size: 10 mL  
Dilution: 100

<u>Surrogate</u>	<u>%R</u>	<u>Qual</u>	<u>%R Limits</u>
Dibromofluoromethane (surrogate)	103		75-127
1,2-Dichloroethane-d4 (surrogate)	99		75-134
Toluene-d8 (surrogate)	101		75-125
Bromofluorobenzene (surrogate)	94		75-125

Notes:

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E - concentration exceeded the calibration range and is estimated.

Authorized: Monika Santucci  
Date: May 3, 2005 Monika Santucci

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**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4055  
Sample Description: PES-MP1  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R

Collected: 04/19/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042805W1  
Prepared: 04/28/05 %Solids:  
Sample Size: 10 mL  
Dilution: 25

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
Dichlorodifluoromethane	<25.	U	.75	25.	04/28/05
Chloromethane	<25.	U	.85	25.	04/28/05
Vinyl chloride	590.		.78	25.	04/28/05
Bromomethane	<25.	U	2.4	25.	04/28/05
Chloroethane	<25.	U	2.1	25.	04/28/05
Trichlorofluoromethane	<25.	U	.45	25.	04/28/05
Acetone	<250.	U	5.8	250.	04/28/05
1,1-Dichloroethene	<12.	U	.55	12.	04/28/05
Methylene chloride	J 5.9	J	2.2	50.	04/28/05
trans-1,2-Dichloroethene	J 5.5	J	.98	12.	04/28/05
Methyl tert-butyl ether	<12.	U	.80	12.	04/28/05
1,1-Dichloroethane	<12.	U	.55	12.	04/28/05
2-Butanone	<250.	U	17.	250.	04/28/05
cis-1,2-Dichloroethene	69.		.98	12.	04/28/05
Bromochloromethane	<12.	U	1.8	12.	04/28/05
Chloroform	<12.	U	.58	12.	04/28/05
2,2-Dichloropropane	<12.	U	.72	12.	04/28/05
1,2-Dichloroethane	<12.	U	.45	12.	04/28/05
1,1,1-Trichloroethane	<12.	U	1.0	12.	04/28/05
1,1-Dichloropropene	<12.	U	.65	12.	04/28/05
Carbon tetrachloride	<12.	U	.82	12.	04/28/05
Benzene	<12.	U	.42	12.	04/28/05
Dibromomethane	<12.	U	.62	12.	04/28/05
1,2-Dichloropropane	<12.	U	1.2	12.	04/28/05
Trichloroethene	<12.	U	.78	12.	04/28/05
Bromodichloromethane	<12.	U	.58	12.	04/28/05
cis-1,3-Dichloropropene	<12.	U	.65	12.	04/28/05
4-Methyl-2-pentanone	<120.	U	30.	120.	04/28/05
trans-1,3-Dichloropropene	<12.	U	.78	12.	04/28/05
1,1,2-Trichloroethane	<12.	U	1.1	12.	04/28/05
Toluene	J 5.8	J	.40	12.	04/28/05
1,3-Dichloropropane	<12.	U	.70	12.	04/28/05
Dibromochloromethane	<12.	U	.42	12.	04/28/05

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J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

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Authorized: Monika Santucci  
Date: May 3, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4055  
Sample Description: PES-MP1  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055 . 008.32206  
Certification NY No.: 10155R  
Collected: 04/19/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042805W1  
Prepared: 04/28/05 %Solids:  
Sample Size: 10 mL  
Dilution: 25

Parameter	Result	Qual	MDL	PQL	Analyzed	Notes
1,2-Dibromoethane	<12.	U	.80	12.	04/28/05	
Tetrachloroethene	<12.	U	1.2	12.	04/28/05	
1,1,1,2-Tetrachloroethane	<12.	U	1.3	12.	04/28/05	
Chlorobenzene	<12.	U	.42	12.	04/28/05	
1-Chlorohexane	<12.	U	1.4	12.	04/28/05	
Ethylbenzene	<12.	U	.62	12.	04/28/05	
Bromoform	<12.	U	3.4	12.	04/28/05	
Xylene (total)	<12.	U	1.0	12.	04/28/05	
Styrene	<12.	U	.42	12.	04/28/05	
1,1,2,2-Tetrachloroethane	<12.	U	1.2	12.	04/28/05	
1,2,3-Trichloropropane	<12.	U	9.0	12.	04/28/05	
Isopropylbenzene	<12.	U	.38	12.	04/28/05	
Bromobenzene	<12.	U	.60	12.	04/28/05	
n-Propylbenzene	<12.	U	.30	12.	04/28/05	
2-Chlorotoluene	<12.	U	.70	12.	04/28/05	
4-Chlorotoluene	<12.	U	.35	12.	04/28/05	
1,3,5-Trimethylbenzene	<12.	U	.80	12.	04/28/05	
tert-Butylbenzene	<12.	U	.42	12.	04/28/05	
n-Butylbenzene	<12.	U	1.2	12.	04/28/05	
1,2,4-Trimethylbenzene	<12.	U	.60	12.	04/28/05	
sec-Butylbenzene	<12.	U	.48	12.	04/28/05	
1,3-Dichlorobenzene	<12.	U	.52	12.	04/28/05	
1,4-Dichlorobenzene	<12.	U	.98	12.	04/28/05	
p-Isopropyltoluene	<12.	U	.55	12.	04/28/05	
1,2-Dichlorobenzene	<12.	U	1.7	12.	04/28/05	
1,2-Dibromo-3-chloropropane	<25.	U	5.5	25.	04/28/05	
1,2,4-Trichlorobenzene	<25.	U	3.4	25.	04/28/05	
Naphthalene	<25.	U	3.2	25.	04/28/05	
Hexachlorobutadiene	<25.	U	3.6	25.	04/28/05	
1,2,3-Trichlorobenzene	<25.	U	3.5	25.	04/28/05	

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Date: May 3, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4055  
Sample Description: PES-MPI  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R

Collected: 04/19/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042805W1  
Prepared: 04/28/05 %Solids:  
Sample Size: 10 mL  
Dilution: 25

<b>Surrogate</b>	<b>%R</b>	<b>Qual</b>	<b>%R Limits</b>
Dibromofluoromethane (surrogate)	105		75- 127
1,2-Dichloroethane-d4 (surrogate)	99		75- 134
Toluene-d8 (surrogate)	102		75- 125
Bromofluorobenzene (surrogate)	95		75- 125

Notes:

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J - reported value is estimated. D - Result is diluted.  
E - concentration exceeded the calibration range and is estimated.

Authorized: Monika Santucci  
Date: May 3, 2005 Monika Santucci

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**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4056  
Sample Description: PES-MP2  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/19/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042805W1  
Prepared: 04/28/05 %Solids:  
Sample Size: 10 mL  
Dilution: 25

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
Dichlorodifluoromethane	<25.	U	.75	25.	04/28/05
Chloromethane	<25.	U	.85	25.	04/28/05
Vinyl chloride	380.		.78	25.	04/28/05
Bromomethane	<25.	U	2.4	25.	04/28/05
Chloroethane	<25.	U	2.1	25.	04/28/05
Trichlorofluoromethane	<25.	U	.45	25.	04/28/05
Acetone	<250.	U	5.8	250.	04/28/05
1,1-Dichloroethene	<12.	U	.55	12.	04/28/05
Methylene chloride	J 3.5	J	2.2	50.	04/28/05
trans-1,2-Dichloroethene	J 11.	J	.98	12.	04/28/05
Methyl tert-butyl ether	<12.	U	.80	12.	04/28/05
1,1-Dichloroethane	<12.	U	.55	12.	04/28/05
2-Butanone	<250.	U	17.	250.	04/28/05
cis-1,2-Dichloroethene	300.		.98	12.	04/28/05
Bromochloromethane	<12.	U	1.8	12.	04/28/05
Chloroform	<12.	U	.58	12.	04/28/05
2,2-Dichloropropane	<12.	U	.72	12.	04/28/05
1,2-Dichloroethane	<12.	U	.45	12.	04/28/05
1,1,1-Trichloroethane	<12.	U	1.0	12.	04/28/05
1,1-Dichloropropene	<12.	U	.65	12.	04/28/05
Carbon tetrachloride	<12.	U	.82	12.	04/28/05
Benzene	<12.	U	.42	12.	04/28/05
Dibromomethane	<12.	U	.62	12.	04/28/05
1,2-Dichloropropane	<12.	U	1.2	12.	04/28/05
Trichloroethene	<12.	U	.78	12.	04/28/05
Bromodichloromethane	<12.	U	.58	12.	04/28/05
cis-1,3-Dichloropropene	<12.	U	.65	12.	04/28/05
4-Methyl-2-pentanone	<120.	U	30.	120.	04/28/05
trans-1,3-Dichloropropene	<12.	U	.78	12.	04/28/05
1,1,2-Trichloroethane	<12.	U	1.1	12.	04/28/05
Toluene	J 6.3	J	.40	12.	04/28/05
1,3-Dichloropropane	<12.	U	.70	12.	04/28/05
Dibromochloromethane	<12.	U	.42	12.	04/28/05

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Authorized: Monika Santucci  
Date: May 3, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4056  
Sample Description: PES-MP2  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/19/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042805W1  
Prepared: 04/28/05 %Solids:  
Sample Size: 10 mL  
Dilution: 25

Parameter	Result	Qual	MDL	PQL	Analyzed	Notes
1,2-Dibromoethane	<12.	U	.80	12.	04/28/05	
Tetrachloroethene	<12.	U	1.2	12.	04/28/05	
1,1,1,2-Tetrachloroethane	<12.	U	1.3	12.	04/28/05	
Chlorobenzene	<12.	U	.42	12.	04/28/05	
1-Chlorohexane	<12.	U	1.4	12.	04/28/05	
Ethylbenzene	<12.	U	.62	12.	04/28/05	
Bromoform	<12.	U	3.4	12.	04/28/05	
Xylene (total)	<12.	U	1.0	12.	04/28/05	
Styrene	<12.	U	.42	12.	04/28/05	
1,1,2,2-Tetrachloroethane	<12.	U	1.2	12.	04/28/05	
1,2,3-Trichloropropane	<12.	U	9.0	12.	04/28/05	
Isopropylbenzene	<12.	U	.38	12.	04/28/05	
Bromobenzene	<12.	U	.60	12.	04/28/05	
n-Propylbenzene	<12.	U	.30	12.	04/28/05	
2-Chlorotoluene	<12.	U	.70	12.	04/28/05	
4-Chlorotoluene	<12.	U	.35	12.	04/28/05	
1,3,5-Trimethylbenzene	<12.	U	.80	12.	04/28/05	
tert-Butylbenzene	<12.	U	.42	12.	04/28/05	
n-Butylbenzene	<12.	U	1.2	12.	04/28/05	
1,2,4-Trimethylbenzene	<12.	U	.60	12.	04/28/05	
sec-Butylbenzene	<12.	U	.48	12.	04/28/05	
1,3-Dichlorobenzene	<12.	U	.52	12.	04/28/05	
1,4-Dichlorobenzene	<12.	U	.98	12.	04/28/05	
p-Isopropyltoluene	<12.	U	.55	12.	04/28/05	
1,2-Dichlorobenzene	<12.	U	1.7	12.	04/28/05	
1,2-Dibromo-3-chloropropane	<25.	U	5.5	25.	04/28/05	
1,2,4-Trichlorobenzene	<25.	U	3.4	25.	04/28/05	
Naphthalene	<25.	U	3.2	25.	04/28/05	
Hexachlorobutadiene	<25.	U	3.6	25.	04/28/05	
1,2,3-Trichlorobenzene	<25.	U	3.5	25.	04/28/05	

B - Analyte detected above the PQL in the associated Prep Blank.

# - Outside control limits U - Undetected at the reported level.

J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

Authorized: Monika Santucci

Date: May 3, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4056  
Sample Description: PES-MP2  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R

Collected: 04/19/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042805W1  
Prepared: 04/28/05 %Solids:  
Sample Size: 10 mL  
Dilution: 25

<u>Surrogate</u>	<u>%R</u>	<u>Qual</u>	<u>%R Limits</u>
Dibromofluoromethane (surrogate)	101		75-127
1,2-Dichloroethane-d4 (surrogate)	97		75-134
Toluene-d8 (surrogate)	102		75-125
Bromofluorobenzene (surrogate)	95		75-125

Notes:

B - Analyte detected above the PQL in the associated Prep Blank.  
# - Outside control limits U - Undetected at the reported level.  
J - reported value is estimated. D - Result is diluted.  
E - concentration exceeded the calibration range and is estimated.

Authorized: Monika Santucci  
Date: May 3, 2005

Monika Santucci

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**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4057  
Sample Description: PES-MP6  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R

Collected: 04/18/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042905W1  
Prepared: 04/29/05 %Solids:  
Sample Size: 10 mL  
Dilution: 5

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
Dichlorodifluoromethane	<5.0	U	.15	5.0	04/29/05
Chloromethane	<5.0	U	.17	5.0	04/29/05
Vinyl chloride	J 3.0	J	.16	5.0	04/29/05
Bromomethane	<5.0	U	.48	5.0	04/29/05
Chloroethane	<5.0	U	.42	5.0	04/29/05
Trichlorofluoromethane	<5.0	U	.090	5.0	04/29/05
Acetone	<50.	U	1.2	50.	04/29/05
1,1-Dichloroethene	<2.5	U	.11	2.5	04/29/05
Methylene chloride	<10.	U	.44	10.	04/29/05
trans-1,2-Dichloroethene	24.		.20	2.5	04/29/05
Methyl tert-butyl ether	<2.5	U	.16	2.5	04/29/05
1,1-Dichloroethane	<2.5	U	.11	2.5	04/29/05
2-Butanone	<50.	U	3.4	50.	04/29/05
cis-1,2-Dichloroethene	85.		.20	2.5	04/29/05
Bromochloromethane	<2.5	U	.37	2.5	04/29/05
Chloroform	<2.5	U	.12	2.5	04/29/05
2,2-Dichloropropane	<2.5	U	.14	2.5	04/29/05
1,2-Dichloroethane	<2.5	U	.090	2.5	04/29/05
1,1,1-Trichloroethane	<2.5	U	.20	2.5	04/29/05
1,1-Dichloropropene	<2.5	U	.13	2.5	04/29/05
Carbon tetrachloride	<2.5	U	.16	2.5	04/29/05
Benzene	<2.5	U	.085	2.5	04/29/05
Dibromomethane	<2.5	U	.12	2.5	04/29/05
1,2-Dichloropropane	<2.5	U	.24	2.5	04/29/05
Trichloroethene	5.8		.16	2.5	04/29/05
Bromodichloromethane	<2.5	U	.12	2.5	04/29/05
cis-1,3-Dichloropropene	<2.5	U	.13	2.5	04/29/05
4-Methyl-2-pentanone	<25.	U	6.0	25.	04/29/05
trans-1,3-Dichloropropene	<2.5	U	.16	2.5	04/29/05
1,1,2-Trichloroethane	<2.5	U	.22	2.5	04/29/05
Toluene	J .62	J	.080	2.5	04/29/05
1,3-Dichloropropane	<2.5	U	.14	2.5	04/29/05
Dibromochloromethane	<2.5	U	.085	2.5	04/29/05

B - Analyte detected above the PQL in the associated Prep Blank.

# - Outside control limits U - Undetected at the reported level.

J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: Monika Santucci  
Date: May 3, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4057  
Sample Description: PES-MP6  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055, 008.32206  
Certification NY No.: 10155R

Collected: 04/18/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042905W1  
Prepared: 04/29/05 %Solids:  
Sample Size: 10 mL  
Dilution: 5

Parameter	Result	Qual	MDL	PQL	Analyzed	Notes
1,2-Dibromoethane	<2.5	U	.16	2.5	04/29/05	
Tetrachloroethene	<2.5	U	.23	2.5	04/29/05	
1,1,1,2-Tetrachloroethane	<2.5	U	.26	2.5	04/29/05	
Chlorobenzene	<2.5	U	.085	2.5	04/29/05	
1-Chlorohexane	<2.5	U	.27	2.5	04/29/05	
Ethylbenzene	<2.5	U	.12	2.5	04/29/05	
Bromoform	<2.5	U	.67	2.5	04/29/05	
Xylene (total)	<2.5	U	.20	2.5	04/29/05	
Styrene	<2.5	U	.085	2.5	04/29/05	
1,1,2,2-Tetrachloroethane	<2.5	U	.23	2.5	04/29/05	
1,2,3-Trichloropropane	<2.5	U	1.8	2.5	04/29/05	
Isopropylbenzene	<2.5	U	.075	2.5	04/29/05	
Bromobenzene	<2.5	U	.12	2.5	04/29/05	
n-Propylbenzene	<2.5	U	.060	2.5	04/29/05	
2-Chlorotoluene	<2.5	U	.14	2.5	04/29/05	
4-Chlorotoluene	<2.5	U	.070	2.5	04/29/05	
1,3,5-Trimethylbenzene	<2.5	U	.16	2.5	04/29/05	
tert-Butylbenzene	<2.5	U	.085	2.5	04/29/05	
n-Butylbenzene	<2.5	U	.24	2.5	04/29/05	
1,2,4-Trimethylbenzene	<2.5	U	.12	2.5	04/29/05	
sec-Butylbenzene	<2.5	U	.095	2.5	04/29/05	
1,3-Dichlorobenzene	<2.5	U	.10	2.5	04/29/05	
1,4-Dichlorobenzene	<2.5	U	.20	2.5	04/29/05	
p-Isopropyltoluene	<2.5	U	.11	2.5	04/29/05	
1,2-Dichlorobenzene	<2.5	U	.34	2.5	04/29/05	
1,2-Dibromo-3-chloropropane	<5.0	U	1.1	5.0	04/29/05	
1,2,4-Trichlorobenzene	<5.0	U	.67	5.0	04/29/05	
Naphthalene	<5.0	U	.64	5.0	04/29/05	
Hexachlorobutadiene	<5.0	U	.73	5.0	04/29/05	
1,2,3-Trichlorobenzene	<5.0	U	.70	5.0	04/29/05	

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**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4057  
Sample Description: PES-MP6  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/18/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042905W1  
Prepared: 04/29/05 %Solids:  
Sample Size: 10 mL  
Dilution: 5

<b>Surrogate</b>	<b>%R</b>	<b>Qual</b>	<b>%R Limits</b>
Dibromofluoromethane (surrogate)	105		75-127
1,2-Dichloroethane-d4 (surrogate)	101		75-134
Toluene-d8 (surrogate)	102		75-125
Bromofluorobenzene (surrogate)	95		75-125

Notes:

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Authorized: Monika Santucci  
Date: May 3, 2005 Monika Santucci

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**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4058  
Sample Description: PES-MP7  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/18/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042905W1  
Prepared: 04/29/05 %Solids:  
Sample Size: 10 mL  
Dilution: 10

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
Dichlorodifluoromethane	<10.	U	.30	10.	04/29/05
Chloromethane	<10.	U	.34	10.	04/29/05
Vinyl chloride	J 4.6	J	.31	10.	04/29/05
Bromomethane	<10.	U	.97	10.	04/29/05
Chloroethane	<10.	U	.83	10.	04/29/05
Trichlorofluoromethane	<10.	U	.18	10.	04/29/05
Acetone	<100.	U	2.3	100.	04/29/05
1,1-Dichloroethene	<5.0	U	.22	5.0	04/29/05
Methylene chloride	<20.	U	.89	20.	04/29/05
trans-1,2-Dichloroethene	28.		.39	5.0	04/29/05
Methyl tert-butyl ether	<5.0	U	.32	5.0	04/29/05
1,1-Dichloroethane	<5.0	U	.22	5.0	04/29/05
2-Butanone	<100.	U	6.8	100.	04/29/05
cis-1,2-Dichloroethene	190.		.39	5.0	04/29/05
Bromochloromethane	<5.0	U	.74	5.0	04/29/05
Chloroform	<5.0	U	.23	5.0	04/29/05
2,2-Dichloropropane	<5.0	U	.29	5.0	04/29/05
1,2-Dichloroethane	<5.0	U	.18	5.0	04/29/05
1,1,1-Trichloroethane	<5.0	U	.41	5.0	04/29/05
1,1-Dichloropropene	<5.0	U	.26	5.0	04/29/05
Carbon tetrachloride	<5.0	U	.33	5.0	04/29/05
Benzene	<5.0	U	.17	5.0	04/29/05
Dibromomethane	<5.0	U	.25	5.0	04/29/05
1,2-Dichloropropane	<5.0	U	.47	5.0	04/29/05
Trichloroethene	<5.0	U	.31	5.0	04/29/05
Bromodichloromethane	<5.0	U	.23	5.0	04/29/05
cis-1,3-Dichloropropene	<5.0	U	.26	5.0	04/29/05
4-Methyl-2-pentanone	<50.	U	12.	50.	04/29/05
trans-1,3-Dichloropropene	<5.0	U	.31	5.0	04/29/05
1,1,2-Trichloroethane	<5.0	U	.43	5.0	04/29/05
Toluene	<5.0	U	.16	5.0	04/29/05
1,3-Dichloropropane	<5.0	U	.28	5.0	04/29/05
Dibromochloromethane	<5.0	U	.17	5.0	04/29/05

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Date: May 3, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4058  
Sample Description: PES-MP7  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R

Collected: 04/18/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042905W1  
Prepared: 04/29/05 %Solids:  
Sample Size: 10 mL  
Dilution: 10

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
1,2-Dibromoethane	<5.0	U	.32	5.0	04/29/05
Tetrachloroethene	<5.0	U	.46	5.0	04/29/05
1,1,1,2-Tetrachloroethane	<5.0	U	.53	5.0	04/29/05
Chlorobenzene	<5.0	U	.17	5.0	04/29/05
1-Chlorohexane	<5.0	U	.54	5.0	04/29/05
Ethylbenzene	<5.0	U	.25	5.0	04/29/05
Bromoform	<5.0	U	1.3	5.0	04/29/05
Xylene (total)	<5.0	U	.41	5.0	04/29/05
Styrene	<5.0	U	.17	5.0	04/29/05
1,1,2,2-Tetrachloroethane	<5.0	U	.46	5.0	04/29/05
1,2,3-Trichloropropane	<5.0	U	3.6	5.0	04/29/05
Isopropylbenzene	<5.0	U	.15	5.0	04/29/05
Bromobenzene	<5.0	U	.24	5.0	04/29/05
n-Propylbenzene	<5.0	U	.12	5.0	04/29/05
2-Chlorotoluene	<5.0	U	.28	5.0	04/29/05
4-Chlorotoluene	<5.0	U	.14	5.0	04/29/05
1,3,5-Trimethylbenzene	<5.0	U	.32	5.0	04/29/05
tert-Butylbenzene	<5.0	U	.17	5.0	04/29/05
n-Butylbenzene	<5.0	U	.48	5.0	04/29/05
1,2,4-Trimethylbenzene	<5.0	U	.24	5.0	04/29/05
sec-Butylbenzene	<5.0	U	.19	5.0	04/29/05
1,3-Dichlorobenzene	<5.0	U	.21	5.0	04/29/05
1,4-Dichlorobenzene	<5.0	U	.39	5.0	04/29/05
p-Isopropyltoluene	<5.0	U	.22	5.0	04/29/05
1,2-Dichlorobenzene	<5.0	U	.67	5.0	04/29/05
1,2-Dibromo-3-chloropropane	<10.	U	2.2	10.	04/29/05
1,2,4-Trichlorobenzene	<10.	U	1.3	10.	04/29/05
Naphthalene	<10.	U	1.3	10.	04/29/05
Hexachlorobutadiene	<10.	U	1.5	10.	04/29/05
1,2,3-Trichlorobenzene	<10.	U	1.4	10.	04/29/05

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Date: May 3, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4058  
Sample Description: PES-MP7  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/18/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042905W1  
Prepared: 04/29/05 %Solids:  
Sample Size: 10 mL  
Dilution: 10

<u>Surrogate</u>	<u>#R</u>	<u>Qual</u>	<u>#R Limits</u>
Dibromofluoromethane (surrogate)	104		75-127
1,2-Dichloroethane-d4 (surrogate)	100		75-134
Toluene-d8 (surrogate)	101		75-125
Bromofluorobenzene (surrogate)	93		75-125

Notes:

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# - Outside control limits U - Undetected at the reported level.  
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E - concentration exceeded the calibration range and is estimated.

Authorized: Monika Santucci  
Date: May 3, 2005 Monika Santucci

**O'Brien & Gere  
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**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4059  
Sample Description: WL019  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R

Collected: 04/18/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042905W1  
Prepared: 04/29/05 %Solids:  
Sample Size: 10 mL  
Dilution: 2.5

Parameter	Result	Qual	MDL	PQL	Analyzed	Notes
Dichlorodifluoromethane	<2.5	U	.075	2.5	04/29/05	
Chloromethane	<2.5	U	.085	2.5	04/29/05	
Vinyl chloride	<2.5	U	.078	2.5	04/29/05	
Bromomethane	<2.5	U	.24	2.5	04/29/05	
Chloroethane	<2.5	U	.21	2.5	04/29/05	
Trichlorofluoromethane	<2.5	U	.045	2.5	04/29/05	
Acetone	<25.	U	.58	25.	04/29/05	
1,1-Dichloroethene	J .46	J	.055	1.2	04/29/05	
Methylene chloride	<5.0	U	.22	5.0	04/29/05	
trans-1,2-Dichloroethene	16.		.098	1.2	04/29/05	
Methyl tert-butyl ether	<1.2	U	.080	1.2	04/29/05	
1,1-Dichloroethane	<1.2	U	.055	1.2	04/29/05	
2-Butanone	<25.	U	1.7	25.	04/29/05	
cis-1,2-Dichloroethene	73.		.098	1.2	04/29/05	
Bromochloromethane	<1.2	U	.18	1.2	04/29/05	
Chloroform	<1.2	U	.058	1.2	04/29/05	
2,2-Dichloropropane	<1.2	U	.072	1.2	04/29/05	
1,2-Dichloroethane	<1.2	U	.045	1.2	04/29/05	
1,1,1-Trichloroethane	<1.2	U	.10	1.2	04/29/05	
1,1-Dichloropropene	<1.2	U	.065	1.2	04/29/05	
Carbon tetrachloride	<1.2	U	.082	1.2	04/29/05	
Benzene	<1.2	U	.042	1.2	04/29/05	
Dibromomethane	<1.2	U	.062	1.2	04/29/05	
1,2-Dichloropropane	<1.2	U	.12	1.2	04/29/05	
Trichloroethene	74.		.078	1.2	04/29/05	
Bromodichloromethane	<1.2	U	.058	1.2	04/29/05	
cis-1,3-Dichloropropene	<1.2	U	.065	1.2	04/29/05	
4-Methyl-2-pentanone	<12.	U	3.0	12.	04/29/05	
trans-1,3-Dichloropropene	<1.2	U	.078	1.2	04/29/05	
1,1,2-Trichloroethane	<1.2	U	.11	1.2	04/29/05	
Toluene	<1.2	U	.040	1.2	04/29/05	
1,3-Dichloropropane	<1.2	U	.070	1.2	04/29/05	
Dibromochloromethane	<1.2	U	.042	1.2	04/29/05	

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Authorized: Monika Santucci

Date: May 3, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4059  
Sample Description: WL019  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055, 008.32206  
Certification NY No.: 10155R

Collected: 04/18/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042905W1  
Prepared: 04/29/05 %Solids:  
Sample Size: 10 mL  
Dilution: 2.5

Parameter	Result	Qual	MDL	PQL	Analyzed	Notes
1,2-Dibromoethane	<1.2	U	.080	1.2	04/29/05	
Tetrachloroethene	<1.2	U	.12	1.2	04/29/05	
1,1,1,2-Tetrachloroethane	<1.2	U	.13	1.2	04/29/05	
Chlorobenzene	<1.2	U	.042	1.2	04/29/05	
1-Chlorohexane	<1.2	U	.14	1.2	04/29/05	
Ethylbenzene	<1.2	U	.062	1.2	04/29/05	
Bromoform	<1.2	U	.34	1.2	04/29/05	
Xylene (total)	<1.2	U	.10	1.2	04/29/05	
Styrene	<1.2	U	.042	1.2	04/29/05	
1,1,2,2-Tetrachloroethane	<1.2	U	.12	1.2	04/29/05	
1,2,3-Trichloropropane	<1.2	U	.90	1.2	04/29/05	
Isopropylbenzene	<1.2	U	.038	1.2	04/29/05	
Bromobenzene	<1.2	U	.060	1.2	04/29/05	
n-Propylbenzene	<1.2	U	.030	1.2	04/29/05	
2-Chlorotoluene	<1.2	U	.070	1.2	04/29/05	
4-Chlorotoluene	<1.2	U	.035	1.2	04/29/05	
1,3,5-Trimethylbenzene	<1.2	U	.080	1.2	04/29/05	
tert-Butylbenzene	<1.2	U	.042	1.2	04/29/05	
n-Butylbenzene	<1.2	U	.12	1.2	04/29/05	
1,2,4-Trimethylbenzene	<1.2	U	.060	1.2	04/29/05	
sec-Butylbenzene	<1.2	U	.048	1.2	04/29/05	
1,3-Dichlorobenzene	<1.2	U	.052	1.2	04/29/05	
1,4-Dichlorobenzene	<1.2	U	.098	1.2	04/29/05	
p-Isopropyltoluene	<1.2	U	.055	1.2	04/29/05	
1,2-Dichlorobenzene	<1.2	U	.17	1.2	04/29/05	
1,2-Dibromo-3-chloropropane	<2.5	U	.55	2.5	04/29/05	
1,2,4-Trichlorobenzene	<2.5	U	.34	2.5	04/29/05	
Naphthalene	<2.5	U	.32	2.5	04/29/05	
Hexachlorobutadiene	<2.5	U	.36	2.5	04/29/05	
1,2,3-Trichlorobenzene	<2.5	U	.35	2.5	04/29/05	

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Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4059  
Sample Description: WL019  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R  
Collected: 04/18/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042905W1  
Prepared: 04/29/05 %Solids:  
Sample Size: 10 mL  
Dilution: 2.5

<b>Surrogate</b>	<b>%R</b>	<b>Qual</b>	<b>%R Limits</b>
Dibromofluoromethane (surrogate)	105		75-127
1,2-Dichloroethane-d4 (surrogate)	99		75-134
Toluene-d8 (surrogate)	101		75-125
Bromofluorobenzene (surrogate)	93		75-125

Notes:

B - Analyte detected above the PQL in the associated Prep Blank.  
# - Outside control limits U - Undetected at the reported level.  
J - reported value is estimated. D - Result is diluted.  
E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: *Monika Santucci*  
Date: May 3, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4060  
Sample Description: PES-MP11  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/19/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042905W1  
Prepared: 04/29/05 %Solids:  
Sample Size: 10 mL  
Dilution: 20

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
Dichlorodifluoromethane	<20.	U	.60	20.	04/29/05
Chloromethane	<20.	U	.68	20.	04/29/05
Vinyl chloride	610.		.62	20.	04/29/05
Bromomethane	<20.	U	1.9	20.	04/29/05
Chloroethane	<20.	U	1.7	20.	04/29/05
Trichlorodifluoromethane	<20.	U	.36	20.	04/29/05
Acetone	<200.	U	4.6	200.	04/29/05
1,1-Dichloroethene	<10.	U	.44	10.	04/29/05
Methylene chloride	<40.	U	1.8	40.	04/29/05
trans-1,2-Dichloroethene	J 5.6	J	.78	10.	04/29/05
Methyl tert-butyl ether	<10.	U	.64	10.	04/29/05
1,1-Dichloroethane	<10.	U	.44	10.	04/29/05
2-Butanone	<200.	U	14.	200.	04/29/05
cis-1,2-Dichloroethene	89.		.78	10.	04/29/05
Bromochloromethane	<10.	U	1.5	10.	04/29/05
Chloroform	<10.	U	.46	10.	04/29/05
2,2-Dichloropropane	<10.	U	.58	10.	04/29/05
1,2-Dichloroethane	<10.	U	.36	10.	04/29/05
1,1,1-Trichloroethane	<10.	U	.82	10.	04/29/05
1,1-Dichloropropene	<10.	U	.52	10.	04/29/05
Carbon tetrachloride	<10.	U	.66	10.	04/29/05
Benzene	<10.	U	.34	10.	04/29/05
Dibromomethane	<10.	U	.50	10.	04/29/05
1,2-Dichloropropane	<10.	U	.94	10.	04/29/05
Trichloroethene	<10.	U	.62	10.	04/29/05
Bromodichloromethane	<10.	U	.46	10.	04/29/05
cis-1,3-Dichloropropene	<10.	U	.52	10.	04/29/05
4-Methyl-2-pentanone	<100.	U	24.	100.	04/29/05
trans-1,3-Dichloropropene	<10.	U	.62	10.	04/29/05
1,1,2-Trichloroethane	<10.	U	.86	10.	04/29/05
Toluene	J 5.7	J	.32	10.	04/29/05
1,3-Dichloropropane	<10.	U	.56	10.	04/29/05
Dibromochloromethane	<10.	U	.34	10.	04/29/05

B - Analyte detected above the PQL in the associated Prep Blank.

# - Outside control limits U - Undetected at the reported level.

J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

Authorized: Monika Santucci  
Date: May 3, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4060  
Sample Description: PES-MP11  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055.008.32206  
Certification NY No.: 10155R  
Collected: 04/19/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042905W1  
Prepared: 04/29/05 %Solids:  
Sample Size: 10 mL  
Dilution: 20

Parameter	Result	Qual	MDL	PQL	Analyzed	Notes
1,2-Dibromoethane	<10.	U	.64	10.	04/29/05	
Tetrachloroethene	<10.	U	.92	10.	04/29/05	
1,1,1,2-Tetrachloroethane	<10.	U	1.1	10.	04/29/05	
Chlorobenzene	<10.	U	.34	10.	04/29/05	
1-Chlorohexane	<10.	U	1.1	10.	04/29/05	
Ethylbenzene	<10.	U	.50	10.	04/29/05	
Bromoform	<10.	U	2.7	10.	04/29/05	
Xylene (total)	<10.	U	.82	10.	04/29/05	
Styrene	<10.	U	.34	10.	04/29/05	
1,1,2,2-Tetrachloroethane	<10.	U	.92	10.	04/29/05	
1,2,3-Trichloropropane	<10.	U	7.2	10.	04/29/05	
Isopropylbenzene	<10.	U	.30	10.	04/29/05	
Bromobenzene	<10.	U	.48	10.	04/29/05	
n-Propylbenzene	<10.	U	.24	10.	04/29/05	
2-Chlorotoluene	<10.	U	.56	10.	04/29/05	
4-Chlorotoluene	<10.	U	.28	10.	04/29/05	
1,3,5-Trimethylbenzene	<10.	U	.64	10.	04/29/05	
tert-Butylbenzene	<10.	U	.34	10.	04/29/05	
n-Butylbenzene	<10.	U	.96	10.	04/29/05	
1,2,4-Trimethylbenzene	<10.	U	.48	10.	04/29/05	
sec-Butylbenzene	<10.	U	.38	10.	04/29/05	
1,3-Dichlorobenzene	<10.	U	.42	10.	04/29/05	
1,4-Dichlorobenzene	<10.	U	.78	10.	04/29/05	
p-Isopropyltoluene	J 2.5	J	.44	10.	04/29/05	
1,2-Dichlorobenzene	<10.	U	1.3	10.	04/29/05	
1,2-Dibromo-3-chloropropane	<20.	U	4.4	20.	04/29/05	
1,2,4-Trichlorobenzene	<20.	U	2.7	20.	04/29/05	
Naphthalene	<20.	U	2.5	20.	04/29/05	
Hexachlorobutadiene	<20.	U	2.9	20.	04/29/05	
1,2,3-Trichlorobenzene	<20.	U	2.8	20.	04/29/05	

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# - Outside control limits U - Undetected at the reported level.

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E - concentration exceeded the calibration range and is estimated.

Authorized: Monika Santucci

Date: May 3, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4060  
Sample Description: PES-MP11  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/19/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042905W1  
Prepared: 04/29/05 %Solids:  
Sample Size: 10 mL  
Dilution: 20

<b>Surrogate</b>	<b>%R</b>	<b>Qual</b>	<b>%R Limits</b>
Dibromofluoromethane (surrogate)	108		75- 127
1,2-Dichloroethane-d4 (surrogate)	101		75- 134
Toluene-d8 (surrogate)	103		75- 125
Bromofluorobenzene (surrogate)	98		75- 125

Notes:

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Authorized: Monika Santucci  
Date: May 3, 2005

Monika Santucci

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

**O'Brien & Gere  
Laboratories, Inc.**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4061  
Sample Description: SB1-5  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

**Analytical Results  
Method: 8260**

Job No.: 0055.008.32206  
Certification NY No.: 10155R  
Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 67.8  
Sample Size: 5.12 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
Dichlorodifluoromethane	<7.2	U	.12	7.2	04/27/05
Chloromethane	<7.2	U	.55	7.2	04/27/05
Vinyl chloride	<7.2	U	.12	7.2	04/27/05
Bromomethane	<7.2	U	.43	7.2	04/27/05
Chloroethane	<7.2	U	.42	7.2	04/27/05
Trichlorofluoromethane	<7.2	U	.12	7.2	04/27/05
Acetone	120.	B	.56	14.	04/27/05
1,1-Dichloroethene	<3.6	U	.20	3.6	04/27/05
Methylene chloride	<7.2	U	.58	7.2	04/27/05
trans-1,2-Dichloroethene	J .90	J	.14	3.6	04/27/05
Methyl tert-butyl ether	<3.6	U	.10	3.6	04/27/05
1,1-Dichloroethane	<3.6	U	.14	3.6	04/27/05
2-Butanone	42.		.20	14.	04/27/05
cis-1,2-Dichloroethene	43.		.16	3.6	04/27/05
Bromochloromethane	<3.6	U	.23	3.6	04/27/05
Chloroform	<3.6	U	.058	3.6	04/27/05
2,2-Dichloropropane	<3.6	U	.13	3.6	04/27/05
1,2-Dichloroethane	<3.6	U	.14	3.6	04/27/05
1,1,1-Trichloroethane	<3.6	U	.14	3.6	04/27/05
1,1-Dichloropropene	<3.6	U	.14	3.6	04/27/05
Carbon tetrachloride	<3.6	U	.16	3.6	04/27/05
Benzene	<3.6	U	.13	3.6	04/27/05
Dibromomethane	<3.6	U	.16	3.6	04/27/05
1,2-Dichloropropane	<3.6	U	.12	3.6	04/27/05
Trichloroethene	<3.6	U	.16	3.6	04/27/05
Bromodichloromethane	<3.6	U	.12	3.6	04/27/05
cis-1,3-Dichloropropene	<3.6	U	.13	3.6	04/27/05
4-Methyl-2-pentanone	<7.2	U	.35	7.2	04/27/05
trans-1,3-Dichloropropene	<3.6	U	.13	3.6	04/27/05
1,1,2-Trichloroethane	<3.6	U	.16	3.6	04/27/05
Toluene	16.		.17	3.6	04/27/05
1,3-Dichloropropane	<3.6	U	.12	3.6	04/27/05
Dibromochloromethane	<3.6	U	.19	3.6	04/27/05

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5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: Monika Santucci  
Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4061  
Sample Description: SB1-5  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

**Analytical Results  
Method: 8260**

Job No.: 0055.008.32206  
Certification NY No.: 10155R  
Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 67.8  
Sample Size: 5.12 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
1,2-Dibromoethane	<3.6	U	.13	3.6	04/27/05
Tetrachloroethene	<3.6	U	.20	3.6	04/27/05
1,1,1,2-Tetrachloroethane	<3.6	U	.16	3.6	04/27/05
Chlorobenzene	<3.6	U	.13	3.6	04/27/05
1-Chlorohexane	<3.6	U	.29	3.6	04/27/05
Ethylbenzene	<3.6	U	.14	3.6	04/27/05
Bromoform	<3.6	U	.086	3.6	04/27/05
Xylene (total)	<3.6	U	.26	3.6	04/27/05
Styrene	<3.6	U	.14	3.6	04/27/05
1,1,2,2-Tetrachloroethane	<3.6	U	.23	3.6	04/27/05
1,2,3-Trichloropropane	<3.6	U	.24	3.6	04/27/05
Isopropylbenzene	<3.6	U	.12	3.6	04/27/05
Bromobenzene	<3.6	U	.22	3.6	04/27/05
n-Propylbenzene	<3.6	U	.13	3.6	04/27/05
2-Chlorotoluene	<3.6	U	.10	3.6	04/27/05
4-Chlorotoluene	<3.6	U	.23	3.6	04/27/05
1,3,5-Trimethylbenzene	<3.6	U	.13	3.6	04/27/05
tert-Butylbenzene	<3.6	U	.19	3.6	04/27/05
n-Butylbenzene	<3.6	U	.17	3.6	04/27/05
1,2,4-Trimethylbenzene	<3.6	U	.16	3.6	04/27/05
sec-Butylbenzene	<3.6	U	.19	3.6	04/27/05
1,3-Dichlorobenzene	<3.6	U	.14	3.6	04/27/05
1,4-Dichlorobenzene	<3.6	U	.19	3.6	04/27/05
p-Isopropyltoluene	J .89	J	.13	3.6	04/27/05
1,2-Dichlorobenzene	<3.6	U	.13	3.6	04/27/05
1,2-Dibromo-3-chloropropane	<7.2	U	.58	7.2	04/27/05
1,2,4-Trichlorobenzene	<7.2	U	.49	7.2	04/27/05
Naphthalene	<7.2	U	.53	7.2	04/27/05
Hexachlorobutadiene	<7.2	U	.56	7.2	04/27/05
1,2,3-Trichlorobenzene	<7.2	U	.72	7.2	04/27/05

B - Analyte detected above the PQL in the associated Prep Blank.

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5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: Monika Santucci  
Date: May 16, 2005

Monika Santucci

# O'Brien & Gere Laboratories, Inc.

# Analytical Results Method: 8260

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4061  
Sample Description: SB1-5  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

Job No.: 0055.008.32206  
Certification NY No.: 10155R  
Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 67.8  
Sample Size: 5.12 g  
Dilution: 1

<u>Surrogate</u>	<u>%R</u>	<u>Qual</u>	<u>%R Limits</u>
Dibromofluoromethane (surrogate)	108		40 - 156
1,2-Dichloroethane-d4 (surrogate)	112		71 - 128
Toluene-d8 (surrogate)	93		75 - 125
Bromofluorobenzene (surrogate)	87		59 - 125

Notes:

B - Analyte detected above the PQL in the associated Prep Blank.

# - Outside control limits U - Undetected at the reported level.

J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

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Authorized: Monika Santucci  
Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4062  
Sample Description: SB1-15  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 61.8  
Sample Size: 5.05 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
Dichlorodifluoromethane	<8.0	U	.13	8.0	04/27/05
Chloromethane	<8.0	U	.61	8.0	04/27/05
Vinyl chloride	130.		.13	8.0	04/27/05
Bromomethane	<8.0	U	.48	8.0	04/27/05
Chloroethane	<8.0	U	.46	8.0	04/27/05
Trichlorodifluoromethane	<8.0	U	.13	8.0	04/27/05
Acetone	160.	B	.62	16.	04/27/05
1,1-Dichloroethene	<4.0	U	.22	4.0	04/27/05
Methylene chloride	J 1.1	J	.64	8.0	04/27/05
trans-1,2-Dichloroethene	17.		.16	4.0	04/27/05
Methyl tert-butyl ether	<4.0	U	.11	4.0	04/27/05
1,1-Dichloroethane	<4.0	U	.16	4.0	04/27/05
2-Butanone	56.		.22	16.	04/27/05
cis-1,2-Dichloroethene	420.	E	.18	4.0	04/27/05
Bromochloromethane	<4.0	U	.26	4.0	04/27/05
Chloroform	<4.0	U	.064	4.0	04/27/05
2,2-Dichloropropane	<4.0	U	.14	4.0	04/27/05
1,2-Dichloroethane	<4.0	U	.16	4.0	04/27/05
1,1,1-Trichloroethane	<4.0	U	.16	4.0	04/27/05
1,1-Dichloropropene	<4.0	U	.16	4.0	04/27/05
Carbon tetrachloride	<4.0	U	.18	4.0	04/27/05
Benzene	<4.0	U	.14	4.0	04/27/05
Dibromomethane	<4.0	U	.18	4.0	04/27/05
1,2-Dichloropropene	<4.0	U	.13	4.0	04/27/05
Trichloroethene	12.		.18	4.0	04/27/05
Bromodichloromethane	<4.0	U	.13	4.0	04/27/05
cis-1,3-Dichloropropene	<4.0	U	.14	4.0	04/27/05
4-Methyl-2-pentanone	<8.0	U	.38	8.0	04/27/05
trans-1,3-Dichloropropene	<4.0	U	.14	4.0	04/27/05
1,1,2-Trichloroethane	<4.0	U	.18	4.0	04/27/05
Toluene	8.8		.19	4.0	04/27/05
1,3-Dichloropropene	<4.0	U	.13	4.0	04/27/05
Dibromochloromethane	<4.0	U	.21	4.0	04/27/05

B - Analyte detected above the PQL in the associated Prep Blank.  
# - Outside control limits U - Undetected at the reported level.

J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: Monika Santucci  
Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4062  
Sample Description: SB1-15  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

**Analytical Results  
Method: 8260**

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 61.8  
Sample Size: 5.05 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
1,2-Dibromoethane	<4.0	U	.14	4.0	04/27/05
Tetrachloroethene	<4.0	U	.22	4.0	04/27/05
1,1,1,2-Tetrachloroethane	<4.0	U	.18	4.0	04/27/05
Chlorobenzene	<4.0	U	.14	4.0	04/27/05
1-Chlorohexane	<4.0	U	.32	4.0	04/27/05
Ethylbenzene	<4.0	U	.16	4.0	04/27/05
Bromoform	<4.0	U	.096	4.0	04/27/05
Xylene (total)	<4.0	U	.29	4.0	04/27/05
Styrene	<4.0	U	.16	4.0	04/27/05
1,1,2,2-Tetrachloroethane	<4.0	U	.26	4.0	04/27/05
1,2,3-Trichloropropane	<4.0	U	.27	4.0	04/27/05
Isopropylbenzene	<4.0	U	.13	4.0	04/27/05
Bromobenzene	<4.0	U	.24	4.0	04/27/05
n-Propylbenzene	<4.0	U	.14	4.0	04/27/05
2-Chlorotoluene	<4.0	U	.11	4.0	04/27/05
4-Chlorotoluene	<4.0	U	.26	4.0	04/27/05
1,3,5-Trimethylbenzene	<4.0	U	.14	4.0	04/27/05
tert-Butylbenzene	<4.0	U	.21	4.0	04/27/05
n-Butylbenzene	<4.0	U	.19	4.0	04/27/05
1,2,4-Trimethylbenzene	<4.0	U	.18	4.0	04/27/05
sec-Butylbenzene	<4.0	U	.21	4.0	04/27/05
1,3-Dichlorobenzene	<4.0	U	.16	4.0	04/27/05
1,4-Dichlorobenzene	<4.0	U	.21	4.0	04/27/05
p-Isopropyltoluene	54.		.14	4.0	04/27/05
1,2-Dichlorobenzene	<4.0	U	.14	4.0	04/27/05
1,2-Dibromo-3-chloropropane	<8.0	U	.64	8.0	04/27/05
1,2,4-Trichlorobenzene	<8.0	U	.54	8.0	04/27/05
Naphthalene	<8.0	U	.59	8.0	04/27/05
Hexachlorobutadiene	<8.0	U	.62	8.0	04/27/05
1,2,3-Trichlorobenzene	<8.0	U	.80	8.0	04/27/05

B - Analyte detected above the PQL in the associated Prep Blank.

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E - concentration exceeded the calibration range and is estimated.

Authorized: Monika Santucci  
Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4062  
Sample Description: SB1-15  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

**Analytical Results  
Method: 8260**

Job No.: 0055 . 008-32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 61.8  
Sample Size: 5.05 g  
Dilution: 1

Surrogate	%R	Qual	%R Limits
Dibromofluoromethane (surrogate)	111		40 - 156
1,2-Dichloroethane-d4 (surrogate)	119		71 - 128
Toluene-d8 (surrogate)	92		75 - 125
Bromofluorobenzene (surrogate)	86		59 - 125

Notes:

B - Analyte detected above the PQL in the associated Prep Blank.  
# - Outside control limits U - Undetected at the reported level.  
J - reported value is estimated. D - Result is diluted.  
E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: Monika Santucci  
Date: May 16, 2005 Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

Client: Parsons  
Project: OUI-Biwall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4062 DL  
Sample Description: SB1-15  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

**Analytical Results  
Method: 8260**

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 61.8  
Sample Size: 1.12 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
Dichlorodifluoromethane	<36.	U	.58	36.	04/27/05
Chloromethane	<36.	U	2.7	36.	04/27/05
Vinyl chloride	130.		.58	36.	04/27/05
Bromomethane	<36.	U	2.2	36.	04/27/05
Chloroethane	<36.	U	2.1	36.	04/27/05
Trichlorodifluoromethane	<36.	U	.58	36.	04/27/05
Acetone	200.	B	2.8	72.	04/27/05
1,1-Dichloroethene	<18.	U	1.0	18.	04/27/05
Methylene chloride	<36.	U	2.9	36.	04/27/05
trans-1,2-Dichloroethene	J 18.	J	.72	18.	04/27/05
Methyl tert-butyl ether	<18.	U	.51	18.	04/27/05
1,1-Dichloroethane	<18.	U	.72	18.	04/27/05
2-Butanone	J 63.	J	1.0	72.	04/27/05
cis-1,2-Dichloroethene	440.		.79	18.	04/27/05
Bromochloromethane	<18.	U	1.2	18.	04/27/05
Chloroform	<18.	U	.29	18.	04/27/05
2,2-Dichloropropane	<18.	U	.65	18.	04/27/05
1,2-Dichloroethane	<18.	U	.72	18.	04/27/05
1,1,1-Trichloroethane	<18.	U	.72	18.	04/27/05
1,1-Dichloropropene	<18.	U	.72	18.	04/27/05
Carbon tetrachloride	<18.	U	.79	18.	04/27/05
Benzene	<18.	U	.65	18.	04/27/05
Dibromomethane	<18.	U	.79	18.	04/27/05
1,2-Dichloropropane	<18.	U	.58	18.	04/27/05
Trichloroethene	J 15.	J	.79	18.	04/27/05
Bromodichloromethane	<18.	U	.58	18.	04/27/05
cis-1,3-Dichloropropene	<18.	U	.65	18.	04/27/05
4-Methyl-2-pentanone	<36.	U	1.7	36.	04/27/05
trans-1,3-Dichloropropene	<18.	U	.65	18.	04/27/05
1,1,2-Trichloroethane	<18.	U	.79	18.	04/27/05
Toluene	J 13.	J	.87	18.	04/27/05
1,3-Dichloropropane	<18.	U	.58	18.	04/27/05
Dibromochloromethane	<18.	U	.94	18.	04/27/05

B - Analyte detected above the PQL in the associated Prep Blank.

# - Outside control limits U - Undetected at the reported level.

J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: Monika Santucci  
Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

Client: Parsons  
Project: OUL-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4062 DL  
Sample Description: SB1-15  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

**Analytical Results  
Method: 8260**

Job No.: 0055.008.32206  
Certification NY No.: 10155R  
Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 61.8  
Sample Size: 1.12 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
1,2-Dibromoethane	<18.	U	.65	18.	04/27/05
Tetrachloroethene	<18.	U	1.0	18.	04/27/05
1,1,1,2-Tetrachloroethane	<18.	U	.79	18.	04/27/05
Chlorobenzene	<18.	U	.65	18.	04/27/05
1-Chlorohexane	<18.	U	1.4	18.	04/27/05
Ethylbenzene	<18.	U	.72	18.	04/27/05
Bromoform	<18.	U	.43	18.	04/27/05
Xylene (total)	<18.	U	1.3	18.	04/27/05
Styrene	<18.	U	.72	18.	04/27/05
1,1,2,2-Tetrachloroethane	<18.	U	1.2	18.	04/27/05
1,2,3-Trichloropropane	<18.	U	1.2	18.	04/27/05
Isopropylbenzene	<18.	U	.58	18.	04/27/05
Bromobenzene	<18.	U	1.1	18.	04/27/05
n-Propylbenzene	<18.	U	.65	18.	04/27/05
2-Chlorotoluene	<18.	U	.51	18.	04/27/05
4-Chlorotoluene	<18.	U	1.2	18.	04/27/05
1,3,5-Trimethylbenzene	<18.	U	.65	18.	04/27/05
tert-Butylbenzene	<18.	U	.94	18.	04/27/05
n-Butylbenzene	<18.	U	.87	18.	04/27/05
1,2,4-Trimethylbenzene	<18.	U	.79	18.	04/27/05
sec-Butylbenzene	<18.	U	.94	18.	04/27/05
1,3-Dichlorobenzene	<18.	U	.72	18.	04/27/05
1,4-Dichlorobenzene	<18.	U	.94	18.	04/27/05
p-Isopropyltoluene	86.		.65	18.	04/27/05
1,2-Dichlorobenzene	<18.	U	.65	18.	04/27/05
1,2-Dibromo-3-chloropropane	<36.	U	2.9	36.	04/27/05
1,2,4-Trichlorobenzene	<36.	U	2.5	36.	04/27/05
Naphthalene	<36.	U	2.7	36.	04/27/05
Hexachlorobutadiene	<36.	U	2.8	36.	04/27/05
1,2,3-Trichlorobenzene	<36.	U	3.6	36.	04/27/05

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Authorized: Monika Santucci  
Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4062 DL  
Sample Description: SB1-15  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

**Analytical Results  
Method: 8260**

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 61.8  
Sample Size: 1.12 g  
Dilution: 1

<u>Surrogate</u>	<u>%R</u>	<u>Qual</u>	<u>%R Limits</u>
Dibromofluoromethane (surrogate)	106		40 - 156
1,2-Dichloroethane-d4 (surrogate)	114		71 - 128
Toluene-d8 (surrogate)	97		75 - 125
Bromofluorobenzene (surrogate)	91		59 - 125

Notes:

B - Analyte detected above the PQL in the associated Prep Blank.  
# - Outside control limits U - Undetected at the reported level.  
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Authorized: Monika Santucci  
Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4063  
Sample Description: SB1-20  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 54.9  
Sample Size: 5.5 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
Dichlorodifluoromethane	<8.3	U	.13	8.3	04/27/05
Chloromethane	<8.3	U	.63	8.3	04/27/05
Vinyl chloride	210.		.13	8.3	04/27/05
Bromomethane	<8.3	U	.50	8.3	04/27/05
Chloroethane	<8.3	U	.48	8.3	04/27/05
Trichlorofluoromethane	<8.3	U	.13	8.3	04/27/05
Acetone	73.	B	.65	17.	04/27/05
1,1-Dichloroethene	<4.1	U	.23	4.1	04/27/05
Methylene chloride	<8.3	U	.66	8.3	04/27/05
trans-1,2-Dichloroethene	18.		.17	4.1	04/27/05
Methyl tert-butyl ether	<4.1	U	.12	4.1	04/27/05
1,1-Dichloroethane	<4.1	U	.17	4.1	04/27/05
2-Butanone	17.		.23	17.	04/27/05
cis-1,2-Dichloroethene	490.	E	.18	4.1	04/27/05
Bromochloromethane	<4.1	U	.26	4.1	04/27/05
Chloroform	<4.1	U	.066	4.1	04/27/05
2,2-Dichloropropane	<4.1	U	.15	4.1	04/27/05
1,2-Dichloroethane	<4.1	U	.17	4.1	04/27/05
1,1,1-Trichloroethane	<4.1	U	.17	4.1	04/27/05
1,1-Dichloropropene	<4.1	U	.17	4.1	04/27/05
Carbon tetrachloride	<4.1	U	.18	4.1	04/27/05
Benzene	<4.1	U	.15	4.1	04/27/05
Dibromomethane	<4.1	U	.18	4.1	04/27/05
1,2-Dichloropropene	<4.1	U	.13	4.1	04/27/05
Trichloroethene	25.		.18	4.1	04/27/05
Bromodichloromethane	<4.1	U	.13	4.1	04/27/05
cis-1,3-Dichloropropene	<4.1	U	.15	4.1	04/27/05
4-Methyl-2-pentanone	<8.3	U	.40	8.3	04/27/05
trans-1,3-Dichloropropene	<4.1	U	.15	4.1	04/27/05
1,1,2-Trichloroethane	<4.1	U	.18	4.1	04/27/05
Toluene	11.		.20	4.1	04/27/05
1,3-Dichloropropane	<4.1	U	.13	4.1	04/27/05
Dibromochloromethane	<4.1	U	.22	4.1	04/27/05

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# - Outside control limits U - Undetected at the reported level.

J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: Monika Santucci  
Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4063  
Sample Description: SB1-20  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 54.9  
Sample Size: 5.5 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
1,2-Dibromoethane	<4.1	U	.15	4.1	04/27/05
Tetrachloroethene	<4.1	U	.23	4.1	04/27/05
1,1,1,2-Tetrachloroethane	<4.1	U	.18	4.1	04/27/05
Chlorobenzene	<4.1	U	.15	4.1	04/27/05
1-Chlorohexane	<4.1	U	.33	4.1	04/27/05
Ethylbenzene	<4.1	U	.17	4.1	04/27/05
Bromoform	<4.1	U	.099	4.1	04/27/05
Xylene (total)	<4.1	U	.30	4.1	04/27/05
Styrene	<4.1	U	.17	4.1	04/27/05
1,1,2,2-Tetrachloroethane	<4.1	U	.26	4.1	04/27/05
1,2,3-Trichloropropane	<4.1	U	.28	4.1	04/27/05
Isopropylbenzene	<4.1	U	.13	4.1	04/27/05
Bromobenzene	<4.1	U	.25	4.1	04/27/05
n-Propylbenzene	<4.1	U	.15	4.1	04/27/05
2-Chlorotoluene	<4.1	U	.12	4.1	04/27/05
4-Chlorotoluene	<4.1	U	.26	4.1	04/27/05
1,3,5-Trimethylbenzene	<4.1	U	.15	4.1	04/27/05
tert-Butylbenzene	<4.1	U	.22	4.1	04/27/05
n-Butylbenzene	<4.1	U	.20	4.1	04/27/05
1,2,4-Trimethylbenzene	<4.1	U	.18	4.1	04/27/05
sec-Butylbenzene	<4.1	U	.22	4.1	04/27/05
1,3-Dichlorobenzene	<4.1	U	.17	4.1	04/27/05
1,4-Dichlorobenzene	<4.1	U	.22	4.1	04/27/05
p-Isopropyltoluene	49.		.15	4.1	04/27/05
1,2-Dichlorobenzene	<4.1	U	.15	4.1	04/27/05
1,2-Dibromo-3-chloropropane	<8.3	U	.66	8.3	04/27/05
1,2,4-Trichlorobenzene	<8.3	U	.56	8.3	04/27/05
Naphthalene	<8.3	U	.61	8.3	04/27/05
Hexachlorobutadiene	<8.3	U	.65	8.3	04/27/05
1,2,3-Trichlorobenzene	<8.3	U	.83	8.3	04/27/05

B - Analyte detected above the PQL in the associated Prep Blank.  
# - Outside control limits U - Undetected at the reported level.

J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: *Monika Santucci*  
Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4063  
Sample Description: SB1-20  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R  
Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 54.9  
Sample Size: 5.5 g  
Dilution: 1

<b>Surrogate</b>	<b>%R</b>	<b>Qual</b>	<b>%R Limits</b>
Dibromofluoromethane (surrogate)	105		40 - 156
1,2-Dichloroethane-d4 (surrogate)	112		71 - 128
Toluene-d8 (surrogate)	97		75 - 125
Bromofluorobenzene (surrogate)	89		59 - 125

Notes:

B - Analyte detected above the PQL in the associated Prep Blank.  
# - Outside control limits U - Undetected at the reported level.  
J - reported value is estimated. D - Result is diluted.  
E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: Monika Santucci  
Date: May 16, 2005 Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4063 DL  
Sample Description: SB1-20  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 54.9  
Sample Size: 1.1 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
Dichlorodifluoromethane	<41.	U	.66	41.	04/27/05
Chloromethane	<41.	U	3.1	41.	04/27/05
Vinyl chloride	270.		.66	41.	04/27/05
Bromomethane	<41.	U	2.5	41.	04/27/05
Chloroethane	<41.	U	2.4	41.	04/27/05
Trichlorofluoromethane	<41.	U	.66	41.	04/27/05
Acetone	140.	B	3.2	83.	04/27/05
1,1-Dichloroethene	<21.	U	1.2	21.	04/27/05
Methylene chloride	<41.	U	3.3	41.	04/27/05
trans-1,2-Dichloroethene	25.		.83	21.	04/27/05
Methyl tert-butyl ether	<21.	U	.58	21.	04/27/05
1,1-Dichloroethane	<21.	U	.83	21.	04/27/05
2-Butanone	J 30.	J	1.2	83..	04/27/05
cis-1,2-Dichloroethene	760.		.91	21.	04/27/05
Bromochloromethane	<21.	U	1.3	21.	04/27/05
Chloroform	<21.	U	.33	21.	04/27/05
2,2-Dichloropropane	<21.	U	.75	21.	04/27/05
1,2-Dichloroethane	<21.	U	.83	21.	04/27/05
1,1,1-Trichloroethane	<21.	U	.83	21.	04/27/05
1,1-Dichloropropene	<21.	U	.83	21.	04/27/05
Carbon tetrachloride	<21.	U	.91	21.	04/27/05
Benzene	<21.	U	.75	21.	04/27/05
Dibromomethane	<21.	U	.91	21.	04/27/05
1,2-Dichloropropane	<21.	U	.66	21.	04/27/05
Trichloroethene	54.		.91	21.	04/27/05
Bromodichloromethane	<21.	U	.66	21.	04/27/05
cis-1,3-Dichloropropene	<21.	U	.75	21.	04/27/05
4-Methyl-2-pentanone	<41.	U	2.0	41.	04/27/05
trans-1,3-Dichloropropene	<21.	U	.75	21.	04/27/05
1,1,2-Trichloroethane	<21.	U	.91	21.	04/27/05
Toluene	J 16.	J	.99	21.	04/27/05
1,3-Dichloropropane	<21.	U	.66	21.	04/27/05
Dibromochloromethane	<21.	U	1.1	21.	04/27/05

B - Analyte detected above the PQL in the associated Prep Blank.

# - Outside control limits U - Undetected at the reported level.

J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: Monika Santucci  
Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4063 DL  
Sample Description: SB1-20  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

**Analytical Results  
Method: 8260**

Job No.: 0055.008.32206  
Certification NY No.: 10155R  
Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 54.9  
Sample Size: 1.1 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
1,2-Dibromoethane	<21.	U	.75	21.	04/27/05
Tetrachloroethene	<21.	U	1.2	21.	04/27/05
1,1,1,2-Tetrachloroethane	<21.	U	.91	21.	04/27/05
Chlorobenzene	<21.	U	.75	21.	04/27/05
1-Chlorohexane	<21.	U	1.7	21.	04/27/05
Ethylbenzene	<21.	U	.83	21.	04/27/05
Bromoform	<21.	U	.50	21.	04/27/05
Xylene (total)	<21.	U	1.5	21.	04/27/05
Styrene	<21.	U	.83	21.	04/27/05
1,1,2,2-Tetrachloroethane	<21.	U	1.3	21.	04/27/05
1,2,3-Trichloropropane	<21.	U	1.4	21.	04/27/05
Isopropylbenzene	<21.	U	.66	21.	04/27/05
Bromobenzene	<21.	U	1.2	21.	04/27/05
n-Propylbenzene	<21.	U	.75	21.	04/27/05
2-Chlorotoluene	<21.	U	.58	21.	04/27/05
4-Chlorotoluene	<21.	U	1.3	21.	04/27/05
1,3,5-Trimethylbenzene	<21.	U	.75	21.	04/27/05
tert-Butylbenzene	<21.	U	1.1	21.	04/27/05
n-Butylbenzene	<21.	U	.99	21.	04/27/05
1,2,4-Trimethylbenzene	<21.	U	.91	21.	04/27/05
sec-Butylbenzene	<21.	U	1.1	21.	04/27/05
1,3-Dichlorobenzene	<21.	U	.83	21.	04/27/05
1,4-Dichlorobenzene	<21.	U	1.1	21.	04/27/05
p-Isopropyltoluene	43.		.75	21.	04/27/05
1,2-Dichlorobenzene	<21.	U	.75	21.	04/27/05
1,2-Dibromo-3-chloropropane	<41.	U	3.3	41.	04/27/05
1,2,4-Trichlorobenzene	<41.	U	2.8	41.	04/27/05
Naphthalene	<41.	U	3.1	41.	04/27/05
Hexachlorobutadiene	<41.	U	3.2	41.	04/27/05
1,2,3-Trichlorobenzene	<41.	U	4.1	41.	04/27/05

B - Analyte detected above the PQL in the associated Prep Blank.

# - Outside control limits U - Undetected at the reported level.

J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: Monika Santucci  
Date: May 16, 2005      Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4063 DL  
Sample Description: SB1-20  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

**Analytical Results  
Method: 8260**

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 54.9  
Sample Size: 1.1 g  
Dilution: 1

<b>Surrogate</b>	<b>%R</b>	<b>Qual</b>	<b>%R Limits</b>
Dibromofluoromethane (surrogate)	104		40 - 156
1,2-Dichloroethane-d4 (surrogate)	114		71 - 128
Toluene-d8 (surrogate)	97		75 - 125
Bromofluorobenzene (surrogate)	94		59 - 125

**Notes:**

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# - Outside control limits U - Undetected at the reported level.  
J - reported value is estimated. D - Result is diluted.  
E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: Monika Santucci  
Date: May 16, 2005 Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biwall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4064  
Sample Description: SB2-7  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 78.5  
Sample Size: 5.22 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
Dichlorodifluoromethane	<6.1	U	.098	6.1	04/27/05
Chloromethane	<6.1	U	.46	6.1	04/27/05
Vinyl chloride	<6.1	U	.098	6.1	04/27/05
Bromomethane	<6.1	U	.37	6.1	04/27/05
Chloroethane	<6.1	U	.35	6.1	04/27/05
Trichlorofluoromethane	<6.1	U	.098	6.1	04/27/05
Acetone	130.	B	.48	12.	04/27/05
1,1-Dichloroethene	<3.1	U	.17	3.1	04/27/05
Methylene chloride	J .66	J	.49	6.1	04/27/05
trans-1,2-Dichloroethene	<3.1	U	.12	3.1	04/27/05
Methyl tert-butyl ether	<3.1	U	.085	3.1	04/27/05
1,1-Dichloroethane	<3.1	U	.12	3.1	04/27/05
2-Butanone	37.		.17	12.	04/27/05
cis-1,2-Dichloroethene	J 3.0	J	.13	3.1	04/27/05
Bromochloromethane	<3.1	U	.20	3.1	04/27/05
Chloroform	<3.1	U	.049	3.1	04/27/05
2,2-Dichloropropane	<3.1	U	.11	3.1	04/27/05
1,2-Dichloroethane	<3.1	U	.12	3.1	04/27/05
1,1,1-Trichloroethane	<3.1	U	.12	3.1	04/27/05
1,1-Dichloropropene	<3.1	U	.12	3.1	04/27/05
Carbon tetrachloride	<3.1	U	.13	3.1	04/27/05
Benzene	<3.1	U	.11	3.1	04/27/05
Dibromomethane	<3.1	U	.13	3.1	04/27/05
1,2-Dichloropropane	<3.1	U	.098	3.1	04/27/05
Trichloroethene	<3.1	U	.13	3.1	04/27/05
Bromodichloromethane	<3.1	U	.098	3.1	04/27/05
cis-1,3-Dichloropropene	<3.1	U	.11	3.1	04/27/05
4-Methyl-2-pentanone	<6.1	U	.29	6.1	04/27/05
trans-1,3-Dichloropropene	<3.1	U	.11	3.1	04/27/05
1,1,2-Trichloroethane	<3.1	U	.13	3.1	04/27/05
Toluene	22.		.15	3.1	04/27/05
1,3-Dichloropropane	<3.1	U	.098	3.1	04/27/05
Dibromochloromethane	<3.1	U	.16	3.1	04/27/05

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Authorized: *Monika Santucci*  
Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4064  
Sample Description: SB2-7  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

**Analytical Results  
Method: 8260**

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 78.5  
Sample Size: 5.22 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
1,2-Dibromoethane	<3.1	U	.11	3.1	04/27/05
Tetrachloroethene	<3.1	U	.17	3.1	04/27/05
1,1,1,2-Tetrachloroethane	<3.1	U	.13	3.1	04/27/05
Chlorobenzene	<3.1	U	.11	3.1	04/27/05
1-Chlorohexane	<3.1	U	.24	3.1	04/27/05
Ethylbenzene	<3.1	U	.12	3.1	04/27/05
Bromoform	<3.1	U	.073	3.1	04/27/05
Xylene (total)	<3.1	U	.22	3.1	04/27/05
Styrene	<3.1	U	.12	3.1	04/27/05
1,1,2,2-Tetrachloroethane	<3.1	U	.20	3.1	04/27/05
1,2,3-Trichloropropane	<3.1	U	.21	3.1	04/27/05
Isopropylbenzene	<3.1	U	.098	3.1	04/27/05
Bromobenzene	<3.1	U	.18	3.1	04/27/05
n-Propylbenzene	<3.1	U	.11	3.1	04/27/05
2-Chlorotoluene	<3.1	U	.085	3.1	04/27/05
4-Chlorotoluene	<3.1	U	.20	3.1	04/27/05
1,3,5-Trimethylbenzene	<3.1	U	.11	3.1	04/27/05
tert-Butylbenzene	<3.1	U	.16	3.1	04/27/05
n-Butylbenzene	<3.1	U	.15	3.1	04/27/05
1,2,4-Trimethylbenzene	<3.1	U	.13	3.1	04/27/05
sec-Butylbenzene	<3.1	U	.16	3.1	04/27/05
1,3-Dichlorobenzene	<3.1	U	.12	3.1	04/27/05
1,4-Dichlorobenzene	<3.1	U	.16	3.1	04/27/05
p-Isopropyltoluene	J .64	J	.11	3.1	04/27/05
1,2-Dichlorobenzene	<3.1	U	.11	3.1	04/27/05
1,2-Dibromo-3-chloropropane	<6.1	U	.49	6.1	04/27/05
1,2,4-Trichlorobenzene	<6.1	U	.41	6.1	04/27/05
Naphthalene	<6.1	U	.45	6.1	04/27/05
Hexachlorobutadiene	<6.1	U	.48	6.1	04/27/05
1,2,3-Trichlorobenzene	<6.1	U	.61	6.1	04/27/05

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Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4064  
Sample Description: SB2-7  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

**Analytical Results  
Method: 8260**

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 78.5  
Sample Size: 5.22 g  
Dilution: 1

<b>Surrogate</b>	<b>%R</b>	<b>Qual</b>	<b>%R Limits</b>
Dibromofluoromethane (surrogate)	108		40 - 156
1,2-Dichloroethane-d4 (surrogate)	113		71 - 128
Toluene-d8 (surrogate)	94		75 - 125
Bromofluorobenzene (surrogate)	91		59 - 125

**Notes:**

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# - Outside control limits U - Undetected at the reported level.  
J - reported value is estimated. D - Result is diluted.  
E - concentration exceeded the calibration range and is estimated.

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Laboratories, Inc.**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4065  
Sample Description: SB2-15  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

**Analytical Results  
Method: 8260**

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 71.0  
Sample Size: 5.18 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
Dichlorodifluoromethane	<6.8	U	.11	6.8	04/27/05
Chloromethane	<6.8	U	.52	6.8	04/27/05
Vinyl chloride	J 1.4	J	.11	6.8	04/27/05
Bromomethane	<6.8	U	.41	6.8	04/27/05
Chloroethane	<6.8	U	.39	6.8	04/27/05
Trichlorofluoromethane	<6.8	U	.11	6.8	04/27/05
Acetone	120.	B	.53	14.	04/27/05
1,1-Dichloroethene	<3.4	U	.19	3.4	04/27/05
Methylene chloride	<6.8	U	.54	6.8	04/27/05
trans-1,2-Dichloroethene	20.		.14	3.4	04/27/05
Methyl tert-butyl ether	<3.4	U	.095	3.4	04/27/05
1,1-Dichloroethane	<3.4	U	.14	3.4	04/27/05
2-Butanone	48.		.19	14.	04/27/05
cis-1,2-Dichloroethene	360.	E	.15	3.4	04/27/05
Bromochloromethane	<3.4	U	.22	3.4	04/27/05
Chloroform	<3.4	U	.054	3.4	04/27/05
2,2-Dichloropropane	<3.4	U	.12	3.4	04/27/05
1,2-Dichloroethane	<3.4	U	.14	3.4	04/27/05
1,1,1-Trichloroethane	<3.4	U	.14	3.4	04/27/05
1,1-Dichloropropene	<3.4	U	.14	3.4	04/27/05
Carbon tetrachloride	<3.4	U	.15	3.4	04/27/05
Benzene	<3.4	U	.12	3.4	04/27/05
Dibromomethane	<3.4	U	.15	3.4	04/27/05
1,2-Dichloropropane	<3.4	U	.11	3.4	04/27/05
Trichloroethene	J 1.5	J	.15	3.4	04/27/05
Bromodichloromethane	<3.4	U	.11	3.4	04/27/05
cis-1,3-Dichloropropene	<3.4	U	.12	3.4	04/27/05
4-Methyl-2-pentanone	<6.8	U	.33	6.8	04/27/05
trans-1,3-Dichloropropene	<3.4	U	.12	3.4	04/27/05
1,1,2-Trichloroethane	<3.4	U	.15	3.4	04/27/05
Toluene	36.		.16	3.4	04/27/05
1,3-Dichloropropane	<3.4	U	.11	3.4	04/27/05
Dibromochloromethane	<3.4	U	.18	3.4	04/27/05

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Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4065  
Sample Description: SB2-15  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

**Analytical Results  
Method: 8260**

Job No.: 0055.008.32206  
Certification NY No.: 10155R  
Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 71.0  
Sample Size: 5.18 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
1,2-Dibromoethane	<3.4	U	.12	3.4	04/27/05
Tetrachloroethene	<3.4	U	.19	3.4	04/27/05
1,1,1,2-Tetrachloroethane	<3.4	U	.15	3.4	04/27/05
Chlorobenzene	<3.4	U	.12	3.4	04/27/05
1-Chlorohexane	<3.4	U	.27	3.4	04/27/05
Ethylbenzene	<3.4	U	.14	3.4	04/27/05
Bromoform	<3.4	U	.082	3.4	04/27/05
Xylene (total)	<3.4	U	.24	3.4	04/27/05
Styrene	<3.4	U	.14	3.4	04/27/05
1,1,2,2-Tetrachloroethane	<3.4	U	.22	3.4	04/27/05
1,2,3-Trichloropropane	<3.4	U	.23	3.4	04/27/05
Isopropylbenzene	<3.4	U	.11	3.4	04/27/05
Bromobenzene	<3.4	U	.20	3.4	04/27/05
n-Propylbenzene	<3.4	U	.12	3.4	04/27/05
2-Chlorotoluene	<3.4	U	.095	3.4	04/27/05
4-Chlorotoluene	<3.4	U	.22	3.4	04/27/05
1,3,5-Trimethylbenzene	<3.4	U	.12	3.4	04/27/05
tert-Butylbenzene	<3.4	U	.18	3.4	04/27/05
n-Butylbenzene	<3.4	U	.16	3.4	04/27/05
1,2,4-Trimethylbenzene	<3.4	U	.15	3.4	04/27/05
sec-Butylbenzene	<3.4	U	.18	3.4	04/27/05
1,3-Dichlorobenzene	<3.4	U	.14	3.4	04/27/05
1,4-Dichlorobenzene	<3.4	U	.18	3.4	04/27/05
p-Isopropyltoluene	260.		.12	3.4	04/27/05
1,2-Dichlorobenzene	<3.4	U	.12	3.4	04/27/05
1,2-Dibromo-3-chloropropane	<6.8	U	.54	6.8	04/27/05
1,2,4-Trichlorobenzene	<6.8	U	.46	6.8	04/27/05
Naphthalene	<6.8	U	.50	6.8	04/27/05
Hexachlorobutadiene	<6.8	U	.53	6.8	04/27/05
1,2,3-Trichlorobenzene	<6.8	U	.68	6.8	04/27/05

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Laboratories, Inc.**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4065  
Sample Description: SB2-15  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

**Analytical Results  
Method: 8260**

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 71.0  
Sample Size: 5.18 g  
Dilution: 1

Surrogate	%R	Qual	%R Limits
Dibromofluoromethane (surrogate)	105		40 - 156
1,2-Dichloroethane-d4 (surrogate)	115		71 - 128
Toluene-d8 (surrogate)	98		75 - 125
Bromo fluoro benzene (surrogate)	91		59 - 125

Notes:

B - Analyte detected above the PQL in the associated Prep Blank.  
# - Outside control limits U - Undetected at the reported level.  
J - reported value is estimated. D - Result is diluted.  
E - concentration exceeded the calibration range and is estimated.

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Authorized: Monika Santucci  
Date: May 16, 2005 Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biwall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4065 DL  
Sample Description: SB2-15  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

Job No.: 0055 . 008.32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 71.0  
Sample Size: 1.9 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
Dichlorodifluoromethane	<19.	U	.30	19.	04/27/05
Chloromethane	<19.	U	1.4	19.	04/27/05
Vinyl chloride	<19.	U	.30	19.	04/27/05
Bromomethane	<19.	U	1.1	19.	04/27/05
Chloroethane	<19.	U	1.1	19.	04/27/05
Trichlorofluoromethane	<19.	U	.30	19.	04/27/05
Acetone	140.	B	1.4	37.	04/27/05
1,1-Dichloroethene	<9.3	U	.52	9.3	04/27/05
Methylene chloride	<19.	U	1.5	19.	04/27/05
trans-1,2-Dichloroethene	15.		.37	9.3	04/27/05
Methyl tert-butyl ether	<9.3	U	.26	9.3	04/27/05
1,1-Dichloroethane	<9.3	U	.37	9.3	04/27/05
2-Butanone	51.		.52	37.	04/27/05
cis-1,2-Dichloroethene	330.		.41	9.3	04/27/05
Bromochloromethane	<9.3	U	.59	9.3	04/27/05
Chloroform	<9.3	U	.15	9.3	04/27/05
2,2-Dichloropropane	<9.3	U	.33	9.3	04/27/05
1,2-Dichloroethane	<9.3	U	.37	9.3	04/27/05
1,1,1-Trichloroethane	<9.3	U	.37	9.3	04/27/05
1,1-Dichloropropene	<9.3	U	.37	9.3	04/27/05
Carbon tetrachloride	<9.3	U	.41	9.3	04/27/05
Benzene	<9.3	U	.33	9.3	04/27/05
Dibromomethane	<9.3	U	.41	9.3	04/27/05
1,2-Dichloropropane	<9.3	U	.30	9.3	04/27/05
Trichloroethene	<9.3	U	.41	9.3	04/27/05
Bromodichloromethane	<9.3	U	.30	9.3	04/27/05
cis-1,3-Dichloropropene	<9.3	U	.33	9.3	04/27/05
4-Methyl-2-pentanone	<19.	U	.89	19.	04/27/05
trans-1,3-Dichloropropene	<9.3	U	.33	9.3	04/27/05
1,1,2-Trichloroethane	<9.3	U	.41	9.3	04/27/05
Toluene	33.		.44	9.3	04/27/05
1,3-Dichloropropane	<9.3	U	.30	9.3	04/27/05
Dibromochloromethane	<9.3	U	.48	9.3	04/27/05

B - Analyte detected above the PQL in the associated Prep Blank.  
# - Outside control limits U - Undetected at the reported level.

J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: Monika Santucci  
Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4065 DL  
Sample Description: SB2-15  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

Job No.: 0055 . 008.32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 71.0  
Sample Size: 1.9 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
1,2-Dibromoethane	<9.3	U	.33	9.3	04/27/05
Tetrachloroethene	<9.3	U	.52	9.3	04/27/05
1,1,1,2-Tetrachloroethane	<9.3	U	.41	9.3	04/27/05
Chlorobenzene	<9.3	U	.33	9.3	04/27/05
1-Chlorohexane	<9.3	U	.74	9.3	04/27/05
Ethylbenzene	<9.3	U	.37	9.3	04/27/05
Bromoform	<9.3	U	.22	9.3	04/27/05
Xylene (total)	<9.3	U	.67	9.3	04/27/05
Styrene	<9.3	U	.37	9.3	04/27/05
1,1,2,2-Tetrachloroethane	<9.3	U	.59	9.3	04/27/05
1,2,3-Trichloropropane	<9.3	U	.63	9.3	04/27/05
Isopropylbenzene	<9.3	U	.30	9.3	04/27/05
Bromobenzene	<9.3	U	.56	9.3	04/27/05
n-Propylbenzene	<9.3	U	.33	9.3	04/27/05
2-Chlorotoluene	<9.3	U	.26	9.3	04/27/05
4-Chlorotoluene	<9.3	U	.59	9.3	04/27/05
1,3,5-Trimethylbenzene	<9.3	U	.33	9.3	04/27/05
tert-Butylbenzene	<9.3	U	.48	9.3	04/27/05
n-Butylbenzene	<9.3	U	.44	9.3	04/27/05
1,2,4-Trimethylbenzene	<9.3	U	.41	9.3	04/27/05
sec-Butylbenzene	<9.3	U	.48	9.3	04/27/05
1,3-Dichlorobenzene	<9.3	U	.37	9.3	04/27/05
1,4-Dichlorobenzene	<9.3	U	.48	9.3	04/27/05
p-Isopropyltoluene	260.		.33	9.3	04/27/05
1,2-Dichlorobenzene	<9.3	U	.33	9.3	04/27/05
1,2-Dibromo-3-chloropropane	<19.	U	1.5	19.	04/27/05
1,2,4-Trichlorobenzene	<19.	U	1.3	19.	04/27/05
Naphthalene	<19.	U	1.4	19.	04/27/05
Hexachlorobutadiene	<19.	U	1.4	19.	04/27/05
1,2,3-Trichlorobenzene	<19.	U	1.9	19.	04/27/05

B - Analyte detected above the PQL in the associated Prep Blank.  
# - Outside control limits U - Undetected at the reported level.

J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: Monika Santucci  
Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4065 DL  
Sample Description: SB2-15  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

**Analytical Results  
Method: 8260**

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 71.0  
Sample Size: 1.9 g  
Dilution: 1

Surrogate	%R	Qual	%R Limits
Dibromofluoromethane (surrogate)	106		40 - 156
1,2-Dichloroethane-d4 (surrogate)	114		71 - 128
Toluene-d8 (surrogate)	96		75 - 125
Bromofluorobenzene (surrogate)	93		59 - 125

Notes:

B - Analyte detected above the PQL in the associated Prep Blank.  
# - Outside control limits U - Undetected at the reported level.  
J - reported value is estimated. D - Result is diluted.  
E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: Monika Santucci  
Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4066  
Sample Description: SB2-20  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 80.1  
Sample Size: 5.11 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
Dichlorodifluoromethane	<6.1	U	.098	6.1	04/27/05
Chloromethane	<6.1	U	.46	6.1	04/27/05
Vinyl chloride	<6.1	U	.098	6.1	04/27/05
Bromomethane	<6.1	U	.37	6.1	04/27/05
Chloroethane	<6.1	U	.35	6.1	04/27/05
Trichlorofluoromethane	<6.1	U	.098	6.1	04/27/05
Acetone	160.	B	.48	12.	04/27/05
1,1-Dichloroethene	<3.1	U	.17	3.1	04/27/05
Methylene chloride	J .65	J	.49	6.1	04/27/05
trans-1,2-Dichloroethene	6.7		.12	3.1	04/27/05
Methyl tert-butyl ether	<3.1	U	.086	3.1	04/27/05
1,1-Dichloroethane	<3.1	U	.12	3.1	04/27/05
2-Butanone	54.		.17	12.	04/27/05
cis-1,2-Dichloroethene	130.		.13	3.1	04/27/05
Bromochloromethane	<3.1	U	.20	3.1	04/27/05
Chloroform	<3.1	U	.049	3.1	04/27/05
2,2-Dichloropropane	<3.1	U	.11	3.1	04/27/05
1,2-Dichloroethane	<3.1	U	.12	3.1	04/27/05
1,1,1-Trichloroethane	<3.1	U	.12	3.1	04/27/05
1,1-Dichloropropene	<3.1	U	.12	3.1	04/27/05
Carbon tetrachloride	<3.1	U	.13	3.1	04/27/05
Benzene	<3.1	U	.11	3.1	04/27/05
Dibromomethane	<3.1	U	.13	3.1	04/27/05
1,2-Dichloropropane	<3.1	U	.098	3.1	04/27/05
Trichloroethene	<3.1	U	.13	3.1	04/27/05
Bromodichloromethane	<3.1	U	.098	3.1	04/27/05
cis-1,3-Dichloropropene	<3.1	U	.11	3.1	04/27/05
4-Methyl-2-pentanone	<6.1	U	.29	6.1	04/27/05
trans-1,3-Dichloropropene	<3.1	U	.11	3.1	04/27/05
1,1,2-Trichloroethane	<3.1	U	.13	3.1	04/27/05
Toluene	8.6		.15	3.1	04/27/05
1,3-Dichloropropane	<3.1	U	.098	3.1	04/27/05
Dibromochloromethane	<3.1	U	.16	3.1	04/27/05

B - Analyte detected above the PQL in the associated Prep Blank.  
# - Outside control limits U - Undetected at the reported level.

J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: *Monika Santucci*

Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4066  
Sample Description: SB2-20  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

Job No.: 0055, 008.32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 80.1  
Sample Size: 5.11 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed	Notes
1,2-Dibromoethane	<3.1	U	.11	3.1	04/27/05	
Tetrachloroethene	<3.1	U	.17	3.1	04/27/05	
1,1,1,2-Tetrachloroethane	<3.1	U	.13	3.1	04/27/05	
Chlorobenzene	<3.1	U	.11	3.1	04/27/05	
1-Chlorohexane	<3.1	U	.24	3.1	04/27/05	
Ethylbenzene	<3.1	U	.12	3.1	04/27/05	
Bromoform	<3.1	U	.073	3.1	04/27/05	
Xylene (total)	<3.1	U	.22	3.1	04/27/05	
Styrene	<3.1	U	.12	3.1	04/27/05	
1,1,2,2-Tetrachloroethane	<3.1	U	.20	3.1	04/27/05	
1,2,3-Trichloropropane	<3.1	U	.21	3.1	04/27/05	
Isopropylbenzene	<3.1	U	.098	3.1	04/27/05	
Bromobenzene	<3.1	U	.18	3.1	04/27/05	
n-Propylbenzene	<3.1	U	.11	3.1	04/27/05	
2-Chlorotoluene	<3.1	U	.086	3.1	04/27/05	
4-Chlorotoluene	<3.1	U	.20	3.1	04/27/05	
1,3,5-Trimethylbenzene	<3.1	U	.11	3.1	04/27/05	
tert-Butylbenzene	<3.1	U	.16	3.1	04/27/05	
n-Butylbenzene	<3.1	U	.15	3.1	04/27/05	
1,2,4-Trimethylbenzene	<3.1	U	.13	3.1	04/27/05	
sec-Butylbenzene	<3.1	U	.16	3.1	04/27/05	
1,3-Dichlorobenzene	<3.1	U	.12	3.1	04/27/05	
1,4-Dichlorobenzene	<3.1	U	.16	3.1	04/27/05	
p-Isopropyltoluene	92.		.11	3.1	04/27/05	
1,2-Dichlorobenzene	<3.1	U	.11	3.1	04/27/05	
1,2-Dibromo-3-chloropropane	<6.1	U	.49	6.1	04/27/05	
1,2,4-Trichlorobenzene	<6.1	U	.42	6.1	04/27/05	
Naphthalene	<6.1	U	.45	6.1	04/27/05	
Hexachlorobutadiene	<6.1	U	.48	6.1	04/27/05	
1,2,3-Trichlorobenzene	<6.1	U	.61	6.1	04/27/05	

B - Analyte detected above the PQL in the associated Prep Blank.

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E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: Monika Santucci

Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4066  
Sample Description: SB2-20  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

**Analytical Results  
Method: 8260**

Job No.: 0055 . 008 . 32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 80.1  
Sample Size: 5.11 g  
Dilution: 1

<b>Surrogate</b>	<b>%R</b>	<b>Qual</b>	<b>%R Limits</b>
Dibromofluoromethane (surrogate)	106		40 - 156
1,2-Dichloroethane-d4 (surrogate)	116		71 - 128
Toluene-d8 (surrogate)	94		75 - 125
Bromofluorobenzene (surrogate)	92		59 - 125

**Notes:**

B - Analyte detected above the PQL in the associated Prep Blank.  
# - Outside control limits U - Undetected at the reported level.  
J - reported value is estimated. D - Result is diluted.  
E - concentration exceeded the calibration range and is estimated.

Authorized: Monika Santucci  
Date: May 16, 2005 Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4067  
Sample Description: SB12-7  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 64.6  
Sample Size: 5.19 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
Dichlorodifluoromethane	<7.5	U	.12	7.5	04/27/05
Chloromethane	<7.5	U	.57	7.5	04/27/05
Vinyl chloride	<7.5	U	.12	7.5	04/27/05
Bromomethane	<7.5	U	.45	7.5	04/27/05
Chloroethane	<7.5	U	.43	7.5	04/27/05
Trichlorofluoromethane	<7.5	U	.12	7.5	04/27/05
Acetone	110.	B	.58	15.	04/27/05
1,1-Dichloroethene	<3.7	U	.21	3.7	04/27/05
Methylene chloride	J .89	J	.60	7.5	04/27/05
trans-1,2-Dichloroethene	J 1.7	J	.15	3.7	04/27/05
Methyl tert-butyl ether	<3.7	U	.10	3.7	04/27/05
1,1-Dichloroethane	<3.7	U	.15	3.7	04/27/05
2-Butanone	33.		.21	15.	04/27/05
cis-1,2-Dichloroethene	9.2		.16	3.7	04/27/05
Bromochloromethane	<3.7	U	.24	3.7	04/27/05
Chloroform	<3.7	U	.060	3.7	04/27/05
2,2-Dichloropropane	<3.7	U	.13	3.7	04/27/05
1,2-Dichloroethane	<3.7	U	.15	3.7	04/27/05
1,1,1-Trichloroethane	<3.7	U	.15	3.7	04/27/05
1,1-Dichloropropene	<3.7	U	.15	3.7	04/27/05
Carbon tetrachloride	<3.7	U	.16	3.7	04/27/05
Benzene	J .81	J	.13	3.7	04/27/05
Dibromomethane	<3.7	U	.16	3.7	04/27/05
1,2-Dichloropropane	<3.7	U	.12	3.7	04/27/05
Trichloroethene	<3.7	U	.16	3.7	04/27/05
Bromodichloromethane	<3.7	U	.12	3.7	04/27/05
cis-1,3-Dichloropropene	<3.7	U	.13	3.7	04/27/05
4-Methyl-2-pentanone	<7.5	U	.36	7.5	04/27/05
trans-1,3-Dichloropropene	<3.7	U	.13	3.7	04/27/05
1,1,2-Trichloroethane	<3.7	U	.16	3.7	04/27/05
Toluene	40.		.18	3.7	04/27/05
1,3-Dichloropropane	<3.7	U	.12	3.7	04/27/05
Dibromochloromethane	<3.7	U	.19	3.7	04/27/05

B - Analyte detected above the PQL in the associated Prep Blank.

# - Outside control limits U - Undetected at the reported level.

J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: Monika Santucci  
Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4067  
Sample Description: SB12-7  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

**Analytical Results  
Method: 8260**

Job No.: 0055 . 008.32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 64.6  
Sample Size: 5.19 g  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
1,2-Dibromoethane	<3.7	U	.13	3.7	04/27/05
Tetrachloroethene	<3.7	U	.21	3.7	04/27/05
1,1,1,2-Tetrachloroethane	<3.7	U	.16	3.7	04/27/05
Chlorobenzene	<3.7	U	.13	3.7	04/27/05
1-Chlorohexane	<3.7	U	.30	3.7	04/27/05
Ethylbenzene	<3.7	U	.15	3.7	04/27/05
Bromoform	<3.7	U	.089	3.7	04/27/05
Xylene (total)	<3.7	U	.27	3.7	04/27/05
Styrene	<3.7	U	.15	3.7	04/27/05
1,1,2,2-Tetrachloroethane	<3.7	U	.24	3.7	04/27/05
1,2,3-Trichloropropane	<3.7	U	.25	3.7	04/27/05
Isopropylbenzene	<3.7	U	.12	3.7	04/27/05
Bromobenzene	<3.7	U	.22	3.7	04/27/05
n-Propylbenzene	<3.7	U	.13	3.7	04/27/05
2-Chlorotoluene	<3.7	U	.10	3.7	04/27/05
4-Chlorotoluene	<3.7	U	.24	3.7	04/27/05
1,3,5-Trimethylbenzene	<3.7	U	.13	3.7	04/27/05
tert-Butylbenzene	<3.7	U	.19	3.7	04/27/05
n-Butylbenzene	<3.7	U	.18	3.7	04/27/05
1,2,4-Trimethylbenzene	<3.7	U	.16	3.7	04/27/05
sec-Butylbenzene	<3.7	U	.19	3.7	04/27/05
1,3-Dichlorobenzene	<3.7	U	.15	3.7	04/27/05
1,4-Dichlorobenzene	<3.7	U	.19	3.7	04/27/05
p-Isopropyltoluene	J 2.7	J	.13	3.7	04/27/05
1,2-Dichlorobenzene	<3.7	U	.13	3.7	04/27/05
1,2-Dibromo-3-chloropropane	<7.5	U	.60	7.5	04/27/05
1,2,4-Trichlorobenzene	<7.5	U	.51	7.5	04/27/05
Naphthalene	<7.5	U	.55	7.5	04/27/05
Hexachlorobutadiene	<7.5	U	.58	7.5	04/27/05
1,2,3-Trichlorobenzene	<7.5	U	.75	7.5	04/27/05

B - Analyte detected above the PQL in the associated Prep Blank.

# - Outside control limits U - Undetected at the reported level.

J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: Monika Santucci  
Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 134  
Sample: F4067  
Sample Description: SB12-7  
Instrument: HP5973 GCMS#3  
Units: ug/Kg Dry weight  
Number of analytes: 63

**Analytical Results  
Method: 8260**

Job No.: 0055 . 008.32206  
Certification NY No.: 10155R

Collected: 04/22/05 Matrix: Solid  
Received: 04/23/05 QC Batch: 042705S3  
Prepared: 04/27/05 %Solids: 64.6  
Sample Size: 5.19 g  
Dilution: 1

<u>Surrogate</u>	<u>%R</u>	<u>Qual</u>	<u>%R Limits</u>
Dibromofluoromethane (surrogate)	107		40 - 156
1,2-Dichloroethane-d4 (surrogate)	113		71 - 128
Toluene-d8 (surrogate)	96		75 - 125
Bromofluorobenzene (surrogate)	92		59 - 125

**Notes:**

B - Analyte detected above the PQL in the associated Prep Blank.  
# - Outside control limits U - Undetected at the reported level.  
J - reported value is estimated. D - Result is diluted.  
E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: *Monika Santucci*  
Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 135  
Sample: F4068  
Sample Description: QC Trip Blank  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/18/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042805W1  
Prepared: 04/28/05 %Solids:  
Sample Size: 10 mL  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
Dichlorodifluoromethane	<1.0	U	.030	1.0	04/28/05
Chloromethane	<1.0	U	.034	1.0	04/28/05
Vinyl chloride	<1.0	U	.031	1.0	04/28/05
Bromomethane	<1.0	U	.097	1.0	04/28/05
Chloroethane	<1.0	U	.083	1.0	04/28/05
Trichlorofluoromethane	<1.0	U	.018	1.0	04/28/05
Acetone	<10.	U	.23	10.	04/28/05
1,1-Dichloroethene	<.50	U	.022	.50	04/28/05
Methylene chloride	<2.0	U	.089	2.0	04/28/05
trans-1,2-Dichloroethene	<.50	U	.039	.50	04/28/05
Methyl tert-butyl ether	<.50	U	.032	.50	04/28/05
1,1-Dichloroethane	<.50	U	.022	.50	04/28/05
2-Butanone	<10.	U	.68	10.	04/28/05
cis-1,2-Dichloroethene	<.50	U	.039	.50	04/28/05
Bromochloromethane	<.50	U	.074	.50	04/28/05
Chloroform	<.50	U	.023	.50	04/28/05
2,2-Dichloropropane	<.50	U	.029	.50	04/28/05
1,2-Dichloroethane	<.50	U	.018	.50	04/28/05
1,1,1-Trichloroethane	<.50	U	.041	.50	04/28/05
1,1-Dichloropropene	<.50	U	.026	.50	04/28/05
Carbon tetrachloride	<.50	U	.033	.50	04/28/05
Benzene	<.50	U	.017	.50	04/28/05
Dibromomethane	<.50	U	.025	.50	04/28/05
1,2-Dichloropropane	<.50	U	.047	.50	04/28/05
Trichloroethene	<.50	U	.031	.50	04/28/05
Bromodichloromethane	<.50	U	.023	.50	04/28/05
cis-1,3-Dichloropropene	<.50	U	.026	.50	04/28/05
4-Methyl-2-pentanone	<5.0	U	1.2	5.0	04/28/05
trans-1,3-Dichloropropene	<.50	U	.031	.50	04/28/05
1,1,2-Trichloroethane	<.50	U	.043	.50	04/28/05
Toluene	<.50	U	.016	.50	04/28/05
1,3-Dichloropropane	<.50	U	.028	.50	04/28/05
Dibromochloromethane	<.50	U	.017	.50	04/28/05

B - Analyte detected above the PQL in the associated Prep Blank.

# - Outside control limits U - Undetected at the reported level.

J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: *Monika Santucci*  
Date: May 3, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 135  
Sample: F4068  
Sample Description: QC Trip Blank  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/18/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042805W1  
Prepared: 04/28/05 %Solids:  
Sample Size: 10 mL  
Dilution: 1

Parameter	Result	Qual	MDL	PQL	Analyzed Notes
1,2-Dibromoethane	<.50	U	.032	.50	04/28/05
Tetrachloroethene	<.50	U	.046	.50	04/28/05
1,1,1,2-Tetrachloroethane	<.50	U	.053	.50	04/28/05
Chlorobenzene	<.50	U	.017	.50	04/28/05
1-Chlorohexane	<.50	U	.054	.50	04/28/05
Ethylbenzene	<.50	U	.025	.50	04/28/05
Bromoform	<.50	U	.13	.50	04/28/05
Xylene (total)	<.50	U	.041	.50	04/28/05
Styrene	<.50	U	.017	.50	04/28/05
1,1,2,2-Tetrachloroethane	<.50	U	.046	.50	04/28/05
1,2,3-Trichloropropane	<.50	U	.36	.50	04/28/05
Isopropylbenzene	<.50	U	.015	.50	04/28/05
Bromobenzene	<.50	U	.024	.50	04/28/05
n-Propylbenzene	<.50	U	.012	.50	04/28/05
2-Chlorotoluene	<.50	U	.028	.50	04/28/05
4-Chlorotoluene	<.50	U	.014	.50	04/28/05
1,3,5-Trimethylbenzene	<.50	U	.032	.50	04/28/05
tert-Butylbenzene	<.50	U	.017	.50	04/28/05
n-Butylbenzene	<.50	U	.048	.50	04/28/05
1,2,4-Trimethylbenzene	<.50	U	.024	.50	04/28/05
sec-Butylbenzene	<.50	U	.019	.50	04/28/05
1,3-Dichlorobenzene	<.50	U	.021	.50	04/28/05
1,4-Dichlorobenzene	<.50	U	.039	.50	04/28/05
p-Isopropyltoluene	<.50	U	.022	.50	04/28/05
1,2-Dichlorobenzene	<.50	U	.067	.50	04/28/05
1,2-Dibromo-3-chloropropane	<1.0	U	.22	1.0	04/28/05
1,2,4-Trichlorobenzene	<1.0	U	.13	1.0	04/28/05
Naphthalene	<1.0	U	.13	1.0	04/28/05
Hexachlorobutadiene	<1.0	U	.15	1.0	04/28/05
1,2,3-Trichlorobenzene	<1.0	U	.14	1.0	04/28/05

B - Analyte detected above the PQL in the associated Prep Blank.

# - Outside control limits U - Undetected at the reported level.

J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

Authorized: Monika Santucci  
Date: May 3, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Method: 8260**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022  
Package#: 135  
Sample: F4068  
Sample Description: QC Trip Blank  
Instrument: HP5973 GC/MS#1  
Units: ug/L  
Number of analytes: 63

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/18/05 Matrix: Water  
Received: 04/23/05 QC Batch: 042805W1  
Prepared: 04/28/05 %Solids:  
Sample Size: 10 mL  
Dilution: 1

<u>Surrogate</u>	<u>%R</u>	<u>Qual</u>	<u>%R Limits</u>
Dibromofluoromethane (surrogate)	101		75-127
1,2-Dichloroethane-d4 (surrogate)	99		75-134
Toluene-d8 (surrogate)	100		75-125
Bromofluorobenzene (surrogate)	91		75-125

Notes:

B - Analyte detected above the PQL in the associated Prep Blank.

# - Outside control limits U - Undetected at the reported level.

J - reported value is estimated. D - Result is diluted.

E - concentration exceeded the calibration range and is estimated.

Authorized: Monika Santucci  
Date: May 3, 2005

Monika Santucci

5000 Brittonfield Parkway / Suite 300, Box 4942 / Syracuse, NY 13221 / (315) 437-0200

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Wet Chemistry**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022

Package#: 134  
Sample: F4061  
Samp. Description: SB1-5

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/22/05 08:15  
Received: 04/23/05 08:38  
Matrix: Solid  
Number of Analytes: 1

Parameter	Result	Q	Units	Method	MDL	PQL Analyzed	QC Batch	Dil	Note
% Total Solids	67.8	%		2540-G		1.0 04/29/05	042905S9	1	

Notes:

Package#: 134  
Sample: F4062  
Samp. Description: SB1-15

Collected: 04/22/05 08:30  
Received: 04/23/05 08:38  
Matrix: Solid  
Number of Analytes: 1

Parameter	Result	Q	Units	Method	MDL	PQL Analyzed	QC Batch	Dil	Note
% Total Solids	61.8	%		2540-G		1.0 04/29/05	042905S9	1	

Notes:

Package#: 134  
Sample: F4063  
Samp. Description: SB1-20

Collected: 04/22/05 08:40  
Received: 04/23/05 08:38  
Matrix: Solid  
Number of Analytes: 1

Parameter	Result	Q	Units	Method	MDL	PQL Analyzed	QC Batch	Dil	Note
% Total Solids	54.9	%		2540-G		1.0 04/29/05	042905S9	1	

Notes:

B - Analyte detected above the PQL in the associated Prep Blank  
U - Undetected at the reported level.

J - Reported value is estimated. D- Result is diluted.

E - Concentration exceeded the calibration range and is estimated.

Authorized: Monika Santucci  
Date: May 16, 2005      Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Wet Chemistry**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022

Package#: 134  
Sample: F4064  
Samp. Description: SB2-7

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/22/05 09:40  
Received: 04/23/05 08:38  
Matrix: Solid  
Number of Analytes: 1

Parameter	Result	Q	Units	Method	MDL	PQL Analyzed	QC Batch	Dil	Note
% Total Solids	78.5	%		2540-G		1.0 04/29/05	042905S9	1	

Notes:

Package#: 134  
Sample: F4065  
Samp. Description: SB2-15

Collected: 04/22/05 09:45  
Received: 04/23/05 08:38  
Matrix: Solid  
Number of Analytes: 1

Parameter	Result	Q	Units	Method	MDL	PQL Analyzed	QC Batch	Dil	Note
% Total Solids	71.0	%		2540-G		1.0 04/29/05	042905S9	1	

Notes:

Package#: 134  
Sample: F4066  
Samp. Description: SB2-20

Collected: 04/22/05 09:55  
Received: 04/23/05 08:38  
Matrix: Solid  
Number of Analytes: 1

Parameter	Result	Q	Units	Method	MDL	PQL Analyzed	QC Batch	Dil	Note
% Total Solids	80.1	%		2540-G		1.0 04/29/05	042905S9	1	

Notes:

B - Analyte detected above the PQL in the associated Prep Blank  
U - Undetected at the reported level.

J - Reported value is estimated. D- Result is diluted.

E - Concentration exceeded the calibration range and is estimated.

Authorized: Monika Santucci  
Date: May 16, 2005

Monika Santucci

**O'Brien & Gere  
Laboratories, Inc.**

**Analytical Results  
Wet Chemistry**

Client: Parsons  
Project: OUI-Biowall-Altus AFB  
Proj. Desc: N47408-99-C-7022

Package#: 134  
Sample: F4067  
Samp. Description: SB12-7

Job No.: 0055.008.32206  
Certification NY No.: 10155R

Collected: 04/22/05 09:00  
Received: 04/23/05 08:38  
Matrix: Solid  
Number of Analytes: 1

Parameter	Result	Q	Units	Method	MDL	PQL Analyzed	QC Batch	Dil	Note
% Total Solids	64.6	%		2540-G		1.0 04/29/05	042905S9	1	

Notes:

B - Analyte detected above the PQL in the associated Prep Blank  
U - Undetected at the reported level.

J - Reported value is estimated. D- Result is diluted.

E - Concentration exceeded the calibration range and is estimated.

Authorized: Monika Santucci  
Date: May 16, 2005      Monika Santucci

# Analytical Analysis Report

---

**Client:** Bruce Henry  
Parsons Engineering Science  
1700 Broadway  
Suite 900  
Denver, CO 80290

**Phone:** (303) 831-8100

**Fax:**

**MI Identifier:** 062CD      **Date Rec:** 04/23/2005      **Report Date:** 07/27/2005

**Client Project #:** 738863.04000      **Client Project Name:** OU1 Biowall - Altus AFB

**Analysis Requested:** VFA

**Project:** OU1 Biowall - Altus AFB

**Comments:**

All samples within this data package were analyzed under U.S. EPA Good Laboratory Practice Standards: Toxic Substances Control Act (40 CFR part 790). All samples were processed according to standard operating procedures. Test results submitted in this data package meet the quality assurance requirements established by Microbial Insights, Inc.

**Reported By:**



Michael J. Kunkel

**Reviewed By:**



Greg A. Davis

---

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## Analysis Summary Report

---

Sample Name:	Date Sampled:	Date Received:	Arrival Condition:	Metabolic Acids (mg/L)					
				Pyruvic	Lactic	Formic	Acetic	Propionic	Butyric
PES-MP3	04/19/2005	04/23/2005	Intact	<4	<1	<1	<1	<1	<1
PES-MP4	04/19/2005	04/23/2005	Intact	<4	<1	<1	<1	<1	<1
PES-MP5	04/20/2005	04/23/2005	Intact	<4	<1	<1	<1	<1	<1
PES-MP8	04/20/2005	04/23/2005	Intact	<4	<1	<1	<1	<1	<1
PES-MP9	04/20/2005	04/23/2005	Intact	<4	<1	<1	<1	<1	<1
PES-MP10	04/20/2005	04/23/2005	Intact	<4	<1	<1	<1	<1	<1

---

## Quality Control Report

---

Compound	MS Recovery %	MSD Recovery %	RPD %	LCS Recovery %
Pyruvic	119.1	104.6	13.0	110.8
Lactic	91.7	88.8	3.2	91.2
Formic	102.1	99.3	2.8	93.5
Acetic	167.1	162.3	2.9	94.1
Propionic	86.6	80.7	7.1	94.2
Butyric	90.7	85.3	6.1	88.3

# Analytical Analysis Report

---

**Client:** Bruce Henry  
Parsons Engineering Science  
1700 Broadway  
Suite 900  
Denver, CO 80290

**Phone:** (303) 831-8100

**Fax:**

**MI Identifier:** 063CD      **Date Rec:** 04/23/2005      **Report Date:** 07/27/2005

**Client Project #:** 735833.08000      **Client Project Name:** OU1 Altus AFB

**Analysis Requested:** VFA

**Project:** OU1 Altus AFB

**Comments:** SUbcontract #735833-30001-00

All samples within this data package were analyzed under U.S. EPA Good Laboratory Practice Standards: Toxic Substances Control Act (40 CFR part 790). All samples were processed according to standard operating procedures. Test results submitted in this data package meet the quality assurance requirements established by Microbial Insights, Inc.

**Reported By:**



Michael J. Kunkel

**Reviewed By:**



Greg A. Davis

---

NOTICE: This report is intended only for the addressee shown above and may contain confidential or privileged information. If the recipient of this material is not the intended recipient or if you have received this in error, please notify Microbial Insights, Inc. immediately. The data and other information in this report represent only the sample(s) analyzed and are rendered upon condition that it is not to be reproduced without approval from Microbial Insights, Inc. Thank you for your cooperation.

## Analysis Summary Report

Sample Name:	Date Sampled:	Date Received:	Arrival Condition:	Metabolic Acids (mg/L)					
				Pyruvic	Lactic	Formic	Acetic	Propionic	Butyric
OU1-04	04/19/2005	04/23/2005	Intact	<4	<1	<1	<1	<1	<1
PES-MP1	04/19/2005	04/23/2005	Intact	<4	<1	<1	<1	<1	<1
PES-MP2	04/19/2005	04/23/2005	Intact	<4	<1	<1	<1	<1	<1
WL019	04/18/2005	04/23/2005	Intact	<4	<1	<1	<1	<1	<1
PES-MP6	04/18/2005	04/23/2005	Intact	<4	<1	<1	<1	<1	<1
PES-MP7	04/18/2005	04/23/2005	Intact	<4	<1	<1	<1	<1	<1
PES-MP11	04/19/2005	04/23/2005	Intact	<4	<1	<1	<1	<1	<1

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## Quality Control Report

---

Compound	MS Recovery %	MSD Recovery %	RPD %	LCS Recovery %
Pyruvic	119.1	104.6	13.0	110.8
Lactic	91.7	88.8	3.2	91.2
Formic	102.1	99.3	2.8	93.5
Acetic	167.1	162.3	2.9	94.1
Propionic	86.6	80.7	7.1	94.2
Butyric	90.7	85.3	6.1	88.3

**Table A-1**

No.	Supplier	Product	Test Concentration (dry weight)	Units	Shuttling Capacity % of 0.5 g/L IHSS Soil Humic Acid standard	Shuttling Capacity Fe Reduced (mM) (Average of duplicates)
1	TeraVita	SB12-7	1.0	g/L	0	0
2	Luscar Ltd	SB2-20	1.0	g/L	0	0
3	Luscar Ltd	SB2-15	1.0	g/L	32.73	0.081
4	Triad	SB2-7	1.0	g/L	29.7	0.0735
5	Live Earth Products	SB1-20	1.0	g/L	46.67	0.1155
6	Monterey AgResources	SB1-15	1.0	g/L	63.03	0.156
7	Humate International	SB1-5	1.0	g/L	78.79	0.195

Shuttling Capacity of control 0.5 g/L IHSS Soil Humic Acid Standard 0.2475 mM Fe reduced



Client Name: Parsons Engineering Science  
Contact: Bruce Henry  
Address: 1700 Broadway  
Suite 900  
Denver, CO 80290

Page: Page 1 of 19  
Lab Proj #: P0504366  
Report Date: 05/04/05  
Client Proj Name: Altus AFB  
Client Proj #: 735833 08000

## Laboratory Results

Total pages in data package: 19

Lab Sample #	Client Sample ID
P0504366-01	OUI-04
P0504366-02	PES-MP1
P0504366-03	PES-MP2
P0504366-04	WL019
P0504366-05	PES-MP6
P0504366-06	PES-MP7
P0504366-07	PES-MP11

Microseeps test results meet all the requirements of the NELAC standards.

Approved By:

The analytical results reported here are reliable and usable to the precision expressed in this report. As required by some regulating authorities, a full discussion of the uncertainty in our analytical results can be obtained at our web site or through customer service. Unless otherwise specified, all results are reported on a wet weight basis.

As a valued client we would appreciate your comments on our service  
Please call customer service at (412)826-5245 or email [bhans@microseeps.com](mailto:bhans@microseeps.com)

**Case Narrative** The percent recovery for the batch MS/MSD analyses for chloride and sulfate was outside of control limits. The unspiked sample concentration was greater than 4 times the spike added. All other QC analyses were acceptable. No further action taken. One of the percent RPDs for the batch duplicate analyses was outside of control limits. The original result (a non-Parsons sample) was just under the PQL and the duplicate value was just above the PQL. Differences at this level are within the expected method error.

Client Name: Parsons Engineering Science  
 Contact: Bruce Henry  
 Address: 1700 Broadway  
 Suite 900  
 Denver, CO 80290

Page: Page 2 of 19  
 Lab Proj #: P0504366  
 Report Date: 05/04/05  
 Client Proj Name: Altus AFB  
 Client Proj #: 735833 08000

Sample Description	Matrix	Lab Sample #		Sampled Date/Time		Received	
OUI-04	Water	P0504366-01		19 Apr. 05	18:15	25 Apr. 05	9:51
Analyte(s)	Flag	Result	PQL	Units	Method #	Analysis Date	By
<b>WetChem</b>							
N Chloride	M	250.0	5.0	mg/L	9056	4/28/05	23:20
Nitrate-Nitrite as N		0.240	0.050	mg/L	HACH-8192	4/27/05	tld
SolubleOrganic Carbon		12.000	5.000	mg/L	9060	4/28/05	md
N Sulfate	M	1600.0	10.0	mg/L	9056	4/29/05	0:04
Total Dissolved Solids(TDS)		2400	10	mg/L	160.1	4/25/05	tld
Total Hardness as CaCO <sub>3</sub>		1300.000	100.000	mg/L	130.2	4/26/05	rh
<b>RiskAnalysis</b>							
Ethane		55.000	5.000	ng/L	AM20GAX	5/2/05	rw
Ethene		71.000	5.000	ng/L	AM20GAX	5/2/05	rw
Methane		13.000	0.015	ug/L	AM20GAX	5/2/05	rw

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

Client Name: Parsons Engineering Science  
 Contact: Bruce Henry  
 Address: 1700 Broadway  
 Suite 900  
 Denver, CO 80290

Page: Page 3 of 19  
 Lab Proj #: P0504366  
 Report Date: 05/04/05  
 Client Proj Name: Altus AFB  
 Client Proj #: 735833 08000

Sample Description	Matrix	Lab Sample #		Sampled Date/Time		Received	
PES-MP1	Water	P0504366-02		19 Apr. 05 10:15		25 Apr. 05 9:51	
Analyte(s)	Flag	Result	PQL	Units	Method #	Analysis Date	By
<b>WetChem</b>							
N Chloride	M	330.0	5	mg/L	9056	4/29/05	1:10
Nitrate-Nitrite as N	J	0.020	0.050	mg/L	HACH-8192	4/27/05	tld
SolubleOrganic Carbon		79.000	10.000	mg/L	9060	4/29/05	md
N Sulfate	M	190.0	1	mg/L	9056	4/29/05	0:48
Total Dissolved Solids(TDS)		2400	10	mg/L	160.1	4/25/05	tld
Total Hardness as CaCO <sub>3</sub>		1500.00	100.00	mg/L	130.2	4/26/05	rh
<b>RiskAnalysis</b>							
Ethane		6.200	5.000	ng/L	AM20GAX	5/2/05	rw
Ethene		3300.000	5.000	ng/L	AM20GAX	5/2/05	rw
Methane		12000.000	0.015	ug/L	AM20GAX	5/2/05	rw

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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 Report Date: 05/04/05  
 Client Proj Name: Altus AFB  
 Client Proj #: 735833.08000

Sample Description	Matrix	Lab Sample #		Sampled Date/Time		Received	
PES-MP2	Water	P0504366-03		19 Apr. 05 12:30		25 Apr. 05 9:51	
Analyte(s)	Flag	Result	PQL	Units	Method #	Analysis Date	By
<b>WetChem</b>							
N Chloride	M	290.0	5	mg/L	9056	4/29/05	1:54
Nitrate-Nitrite as N	U	< 0.050	0.050	mg/L	HACH-8192	4/27/05	tld
SolubleOrganic Carbon		100.000	10.000	mg/L	9060	4/29/05	md
N Sulfate	M	930.0	10	mg/L	9056	4/29/05	2:16
Total Dissolved Solids(TDS)		3300	10	mg/L	160.1	4/25/05	tld
Total Hardness as CaCO <sub>3</sub>		2300.00	100.00	mg/L	130.2	4/26/05	rh
<b>RiskAnalysis</b>							
Ethane		5.100	5.000	ng/L	AM20GAX	5/2/05	rw
Ethene		1600.000	5.000	ng/L	AM20GAX	5/2/05	rw
Methane		14000.000	0.015	ug/L	AM20GAX	5/2/05	rw

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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 Client Proj #: 735833.08000

Sample Description	Matrix	Lab Sample #		Sampled Date/Time		Received	
WL019	Water	P0504366-04		18 Apr. 05 14:00		25 Apr. 05 9:51	
Analyte(s)	Flag	Result	PQL	Units	Method #	Analysis Date	By
<b>WetChem</b>							
N Chloride	M	340.0	5	mg/L	9056	4/29/05	4:28
Nitrate-Nitrite as N	J	0.019	0.050	mg/L	HACH-8192	4/27/05	tld
SolubleOrganic Carbon		10.000	5.000	mg/L	9060	4/28/05	md
N Sulfate	M	1900.0	25	mg/L	9056	4/29/05	4:50
Total Dissolved Solids(TDS)		3200	10	mg/L	160.1	4/25/05	tld
Total Hardness as CaCO <sub>3</sub>		1800.00	100.00	mg/L	130.2	4/26/05	rh
<b>RiskAnalysis</b>							
Ethane		32.000	5.000	ng/L	AM20GAX	5/2/05	rw
Ethene		36.000	5.000	ng/L	AM20GAX	5/2/05	rw
Methane		20.000	0.015	ug/L	AM20GAX	5/2/05	rw

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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 Report Date: 05/04/05  
 Client Proj Name: Altus AFB  
 Client Proj #: 735833 08000

Sample Description	Matrix	Lab Sample #		Sampled Date/Time		Received		
PES-MP6	Water	P0504366-05		18 Apr 05 15:40		25 Apr 05	9:51	
Analyte(s)	Flag	Result	PQL	Units	Method #	Analysis Date		By
<b>WetChem</b>								
N Chloride	M	380.0	5	mg/L	9056	4/29/05	5.34	md
Nitrate-Nitrite as N	J	0.038	0.050	mg/L	HACH-8192	4/27/05		tld
SolubleOrganic Carbon		25.000	5.000	mg/L	9060	4/28/05		md
N Sulfate	M	2200.0	25	mg/L	9056	4/29/05	5.56	md
Total Dissolved Solids(TDS)		3100	10	mg/L	160.1	4/25/05		tld
Total Hardness as CaCO <sub>3</sub>		1600.00	100.00	mg/L	130.2	4/26/05		rh
<b>RiskAnalysis</b>								
Ethane	U	< 5.000	5.000	ng/L	AM20GAX	5/2/05		rw
Ethene		270.000	5.000	ng/L	AM20GAX	5/2/05		rw
Methane		13000.000	0.015	ug/L	AM20GAX	5/2/05		rw

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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 Client Proj #: 735833 08000

Sample Description	Matrix	Lab Sample #		Sampled Date/Time		Received	
PES-MP7	Water	P0504366-06		18 Apr. 05	18:00	25 Apr. 05	9:51
Analyte(s)	Flag	Result	PQL	Units	Method #	Analysis Date	By
<b>WetChem</b>							
N Chloride	M	370.0	5	mg/L	9056	4/29/05	6:40
Nitrate-Nitrite as N	U	< 0.050	0.050	mg/L	HACH-8192	4/27/05	tld
SolubleOrganic Carbon		51.000	5.000	mg/L	9060	4/28/05	md
N Sulfate	M	1300.0	10	mg/L	9056	4/29/05	7:46
Total Dissolved Solids(TDS)		3200	10	mg/L	160.1	4/25/05	tld
Total Hardness as CaCO <sub>3</sub>		1800.00	100.00	mg/L	130.2	4/26/05	rh
<b>RiskAnalysis</b>							
Ethane		31.000	5.000	ng/L	AM20GAX	5/2/05	rw
Ethene		340.000	5.000	ng/L	AM20GAX	5/2/05	rw
Methane		13000.000	0.015	ug/L	AM20GAX	5/2/05	rw

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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 Client Proj Name: Altus AFB  
 Client Proj #: 735833.08000

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>		<u>Sampled Date/Time</u>		<u>Received</u>	
PES-MP11	Water	P0504366-07		18 Apr 05 9:00		25 Apr 05 9:51	
<u>Analyte(s)</u>	<u>Flag</u>	<u>Result</u>	<u>PQL</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>By</u>
<b>WetChem</b>							
N Chloride	M	350.0	5	mg/L	9056	4/29/05	8:30
Nitrate-Nitrite as N	J	0.033	0.050	mg/L	HACH-8192	4/27/05	tld
SolubleOrganic Carbon	M	320.000	50.000	mg/L	9060	4/30/05	md
N Sulfate	M	180.0	5	mg/L	9056	4/29/05	8:30
Total Dissolved Solids(TDS)		2300	10	mg/L	160.1	4/25/05	tld
Total Hardness as CaCO <sub>3</sub>		1600.00	100.00	mg/L	130.2	4/26/05	rh
<b>RiskAnalysis</b>							
Ethane	U	< 5.000	5.000	ng/L	AM20GAX	5/2/05	rw
Ethene		3000.000	5.000	ng/L	AM20GAX	5/2/05	rw
Methane		11000.000	0.015	ug/L	AM20GAX	5/2/05	rw

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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**Prep Method:** Filterable Residue Gravimetric Dried at 180 Degrees C  
**Analysis Method:** Filterable Residue Gravimetric Dried at 180 Degrees C

**M050426010-MB**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>RDL</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
Total Dissolved Solids(TDS)	< 10	mg/L	10		- NA

**M050426010-LCS**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
Total Dissolved Solids(TDS)	180	mg/L	177.00	102.00 79 - 116

**P0504366-07A-DUP**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
Total Dissolved Solids(TDS)	2500	mg/L		- NA	8 33	0 - 24

 Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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**Prep Method:** Total Hardness Titrametric EDTA  
**Analysis Method:** Total Hardness Titrametric EDTA

**M050427012-MB**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>RDL</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
Total Hardness as CaCO <sub>3</sub>	< 10.00 mg/L		10.00		- NA

**M050427012-LCS**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
Total Hardness as CaCO <sub>3</sub>	110.00 mg/L	117.00	94.00	70 - 130

**P0504366-06A-DUP**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
Total Hardness as CaCO <sub>3</sub>	1900.00 mg/L			- NA	5.41	0 - 20

  Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

**Prep Method:** NONO-Manual Cd Reduction Colormetric  
**Analysis Method:** NONO-Manual Cd Reduction Colormetric

**M050427038-MB**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>RDL</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
Nitrate-Nitrite as N	< 0.050 mg/L		0.050		- NA

**M050427038-LCS**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
Nitrate-Nitrite as N	2.400 mg/L	2.99	80.00	73 - 124

**P0504366-04A-MS**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
Nitrate-Nitrite as N	0.140 mg/L	0.20	61.00	57 - 145

**P0504366-04A-MSD**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
Nitrate-Nitrite as N	0.150 mg/L	0.20	66.00	57 - 145	6.90	0 - 18

  Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD. SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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**Prep Method:** Soluble Organic Carbon  
**Analysis Method:** Soluble Organic Carbon

**M050429011-MB**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>RDL</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
SolubleOrganic Carbon	< 5.000 mg/L		5.000		- NA

**M050429011-LCS**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
SolubleOrganic Carbon	21.000 mg/L	19.70	107.00	80 - 120

**P0504366-01A-DUP**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
SolubleOrganic Carbon	15.000 mg/L			- NA	19.0	0 - 20

**P0504366-01A-MS**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
SolubleOrganic Carbon	34.000 mg/L	20.00	110.00	70 - 130

**P0504366-01A-MSD**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
SolubleOrganic Carbon	35.000 mg/L	20.00	115.00	70 - 130	2.90	0 - 20

  Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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**Prep Method:** Soluble Organic Carbon  
**Analysis Method:** Soluble Organic Carbon

**M050430006-MB**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>RDL</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
SolubleOrganic Carbon	< 5.000 mg/L		5.000		- NA

**M050430006-LCS**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
SolubleOrganic Carbon	21.000 mg/L	19.70	107.00	80 - 120

**P0504368-02A-DUP**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
SolubleOrganic Carbon	48.000 mg/L			- NA	0.00	0 - 20

**P0504375-03A-DUP**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
SolubleOrganic Carbon	30 mg/L			- NA	6.90	0 - 20

**P0504437-04A-DUP**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
SolubleOrganic Carbon	3.400 mg/L			- NA	0.00	0 - 20

**P0504368-02A-MS**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
SolubleOrganic Carbon	64.000 mg/L	20.00	80.00	70 - 130

**P0504375-03A-MS**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
SolubleOrganic Carbon	49 mg/L	20.00	105.00	70 - 130

**P0504437-04A-MS**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
SolubleOrganic Carbon	26.000 mg/L	20.00	114.00	70 - 130

**P0504368-02A-MSD**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
SolubleOrganic Carbon	62.000 mg/L	20.00	70.00	70 - 130	3.17	0 - 20

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
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Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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**P0504375-03A-MSD**

	<u>Result</u>		<u>TrueSpikeConc.</u>		<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
SolubleOrganic Carbon	49	mg/L	20.00		105.00	70 - 130	0.00	0 - 20

**P0504437-04A-MSD**

	<u>Result</u>		<u>TrueSpikeConc.</u>		<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
SolubleOrganic Carbon	26.000	mg/L	20.00		114.00	70 - 130	0.00	0 - 20

  Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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Client Proj #: 735833 08000

**Prep Method:** Soluble Organic Carbon  
**Analysis Method:** Soluble Organic Carbon

**M050502003-MB**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>RDL</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
SolubleOrganic Carbon	< 5 000 mg/L		5.000		- NA

**M050502003-LCS**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
SolubleOrganic Carbon	20.000 mg/L	19.70	102.00	80 - 120

**P0504454-01A-DUP**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
SolubleOrganic Carbon	5.900 mg/L			- NA	25.0	0 - 20

**P0504454-01A-MS**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
SolubleOrganic Carbon	25.000 mg/L	20.00	102.00	70 - 130

**P0504454-01A-MSD**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
SolubleOrganic Carbon	26.000 mg/L	20.00	107.00	70 - 130	3.92	0 - 20

  Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used; N - NELAC certified analysis

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Client Proj #: 735833 08000

**Prep Method:** In House Dissolved Gas Sample Preparation  
**Analysis Method:** Analysis of C1-C4 Hydrocarbons in Water

M050502018-MB

	<u>Result</u>	<u>True Spike Conc.</u>	<u>RDL</u>	<u>% Recovery</u>	<u>Ctl Limits</u>
Ethene	< 0.025 ug/L		0.025		- NA
Ethane	< 0.025 ug/L		0.025		- NA

M050502018-LCS

	<u>Result</u>	<u>True Spike Conc.</u>	<u>% Recovery</u>	<u>Ctl Limits</u>
Ethene	22000.000 ng/L	19,445.00	113.00	75 - 125
Ethane	23000.000 ng/L	20,843.00	110.00	75 - 125

M050502018-J.GSD

	<u>Result</u>	<u>True Spike Conc.</u>	<u>% Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
Ethene	21000.000 ng/L	19,445.00	108.00	75 - 125	4.65	0 - 20
Ethane	23000.000 ng/L	20,843.00	110.00	75 - 125	0.00	0 - 20

P0504329-02A-MS

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
Ethene	21000.000 ng/L	19,445.00	108.00	70 - 130
Ethane	22000.000 ng/L	20,843.00	105.00	70 - 130

P0504329-02A-MSD

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
Ethene	21000.000 ng/L	19,445.00	108.00	70 - 130	0.00	0 - 20
Ethane	22000.000 ng/L	20,843.00	105.00	70 - 130	0.00	0 - 20

Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

Client Name: Parsons Engineering Science  
Contact: Bruce Henry  
Address: 1700 Broadway  
Suite 900  
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Lab Proj #: P0504366  
Report Date: 05/04/05  
Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

**Prep Method:** In House Dissolved Gas Sample Preparation  
**Analysis Method:** Analysis of Dissolved Methane in Water

**M050502019-MB**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>RDL</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
Methane	< 0.100 ug/L		0.100		- NA

**M050502019-LCS**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
Methane	460.000 ug/L	411.40	112.00	75 - 125

**M050502019-LCSD**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
Methane	460.000 ug/L	411.40	112.00	75 - 125	0.00	0 - 20

**P0504329-02A-MS**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
Methane	420.000 ug/L	411.40	100.00	70 - 130

**P0504329-02A-MSD**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
Methane	420.000 ug/L	411.40	100.00	70 - 130	0.00	0 - 20

  Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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Client Proj #: 735833 08000

**Prep Method:** Anions by ion chromatography  
**Analysis Method:** Anions by ion chromatography

**M050504011-MB**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>RDL</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
Chloride	< 1.0	mg/L	1		- NA
Sulfate	< 1.0	mg/L	1		- NA

**M050504011-LCS**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
Chloride	10.0	mg/L	10.00	100.00 80 - 120
Sulfate	10.0	mg/L	10.00	100.00 80 - 120

**P0504366-01A-DUP**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
Chloride	230.0	mg/L			- NA	8.33 0 - 20
Sulfate	1600.0	mg/L			- NA	0.00 0 - 20

**P0504366-01A-MS**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
Chloride	320.0	mg/L	50.00	140.00 70 - 130
Sulfate	1600.0	mg/L	50.00	0.00 70 - 130

**P0504366-01A-MSD**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
Chloride	320.0	mg/L	50.00	140.00 70 - 130	0.00	0 - 20
Sulfate	1600.0	mg/L	50.00	0.00 70 - 130	0.00	0 - 20

Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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Lab Proj #: P0504379  
Report Date: Draft  
Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

## Laboratory Results

<u>Lab Sample #</u>	<u>Client Sample ID</u>	Total pages in data package: _____
P0504379-01	SB1-5	
P0504379-02	SB1-15	
P0504379-03	SB1-20	
P0504379-04	SB2-7	
P0504379-05	SB2-15	
P0504379-06	SB2-20	
P0504379-07	SB12-7	

Microseeps test results meet all the requirements of the NELAC standards.

Approved By: \_\_\_\_\_

The analytical results reported here are reliable and usable to the precision expressed in this report. As required by some regulating authorities, a full discussion of the uncertainty in our analytical results can be obtained at our web site or through customer service. Unless otherwise specified, all results are reported on a wet weight basis.

*As a valued client we would appreciate your comments on our service.  
Please call customer service at (412)826-5245 or email [bhans@microseeps.com](mailto:bhans@microseeps.com)*

Case Narrative

Client Name: Parsons Engineering Science  
 Contact: Bruce Henry  
 Address: 1700 Broadway  
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 Lab Proj #: P0504379  
 Report Date: Draft  
 Client Proj Name: Altus AFB  
 Client Proj #: 735833.08000

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>		<u>Sampled Date/Time</u>		<u>Received</u>	
SB1-5	Solid	P0504379-01		22 Apr. 05	8:15	25 Apr. 05 13:09	
<u>Analyte(s)</u>	<u>Flag</u>	<u>Result</u>	<u>PQL</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>By</u>
<b>WetChem</b>							
Acid Volatile Sulfide		1.3	0.2	% dry	WC43	7/8/05	rh
Chromium Extractable Sulfide		1.9	0.2	% dry	WC43	7/9/05	tld
Organic Carbon		29000	42	mg/Kg dry	3.2.13	4/26/05	rh
Strong Acid Divalent Manganese	U	< 0.03	0.03	% dry	WC43	7/8/05	md
Strong Acid Ferric Iron	U	< 0.03	0.03	% dry	WC43	7/8/05	md
Strong Acid Soluble Ferrous Iron		0.37	0.03	% dry	WC43	7/8/05	md
Weak Acid Soluble Divalent Manganese	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferric Iron	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferrous Iron		0.13	0.02	% dry	WC43	7/8/05	md
<b>Organics/Prep</b>							
Percent Solids		60	1.0	%	160.3	4/27/05	jb

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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 Report Date: Draft  
 Client Proj Name: Altus AFB  
 Client Proj #: 735833.08000

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>		<u>Sampled Date/Time</u>		<u>Received</u>	
SB1-15	Solid	P0504379-02		22 Apr. 05	8:30	25 Apr. 05 13:09	
<u>Analyte(s)</u>	<u>Flag</u>	<u>Result</u>	<u>PQL</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>By</u>
<b>WetChem</b>							
Acid Volatile Sulfide		1.3	0.2	% dry	WC43	7/8/05	rh
Chromium Extractable Sulfide		0.98	0.2	% dry	WC43	7/9/05	tld
Organic Carbon		41000	40	mg/Kg dry	3.2.13	4/26/05	rh
Strong Acid Divalent Manganese	U	< 0.03	0.03	% dry	WC43	7/8/05	md
Strong Acid Ferric Iron	U	< 0.03	0.03	% dry	WC43	7/8/05	md
Strong Acid Soluble Ferrous Iron		0.52	0.03	% dry	WC43	7/8/05	md
Weak Acid Soluble Divalent Manganese	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferric Iron	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferrous Iron		0.19	0.02	% dry	WC43	7/8/05	md
<b>Organics/Prep</b>							
Percent Solids		63	1.0	%	160.3	4/27/05	jb

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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 Report Date: Draft  
 Client Proj Name: Altus AFB  
 Client Proj #: 735833.08000

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>		<u>Sampled Date/Time</u>		<u>Received</u>	
SB1-20	Solid	P0504379-03		22 Apr. 05	8:40	25 Apr. 05	13:09
<u>Analyte(s)</u>	<u>Flag</u>	<u>Result</u>	<u>PQL</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>By</u>
<b>WetChem</b>							
Acid Volatile Sulfide		0.69	0.2	% dry	WC43	7/8/05	rh
Chromium Extractable Sulfide		0.78	0.2	% dry	WC43	7/9/05	tld
Organic Carbon		21000	39	mg/Kg dry	3.2.13	4/26/05	rh
Strong Acid Divalent Manganese	U	< 0.03	0.03	% dry	WC43	7/8/05	md
Strong Acid Ferric Iron	U	< 0.03	0.03	% dry	WC43	7/8/05	md
Strong Acid Soluble Ferrous Iron	U	0.05	0.03	% dry	WC43	7/8/05	md
Weak Acid Soluble Divalent Manganese	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferric Iron	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferrous Iron	U	< 0.02	0.02	% dry	WC43	7/8/05	md
<b>Organics/Prep</b>							
Percent Solids		64	1.0	%	160.3	4/27/05	jb

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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 Report Date: Draft  
 Client Proj Name: Altus AFB  
 Client Proj #: 735833.08000

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>		<u>Sampled Date/Time</u>		<u>Received</u>	
SB2-7	Solid	P0504379-04		22 Apr. 05	9:40	25 Apr. 05	13:09
<u>Analyte(s)</u>	<u>Flag</u>	<u>Result</u>	<u>PQL</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>By</u>
<b>WetChem</b>							
Acid Volatile Sulfide		0.90	0.12	% dry	WC43	7/8/05	rh
Chromium Extractable Sulfide		0.64	0.12	% dry	WC43	7/9/05	tld
Organic Carbon		15000	29	mg/Kg dry	3.2.13	4/26/05	rh
Strong Acid Divalent Manganese	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Strong Acid Ferric Iron	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Strong Acid Soluble Ferrous Iron		0.10	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Divalent Manganese	U	< 0.01	0.01	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferric Iron	U	< 0.01	0.01	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferrous Iron		0.03	0.01	% dry	WC43	7/8/05	md
<b>Organics/Prep</b>							
Percent Solids		86	1	%	160.3	4/27/05	jb

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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 Report Date: Draft  
 Client Proj Name: Altus AFB  
 Client Proj #: 735833.08000

Sample Description	Matrix	Lab Sample #		Sampled Date/Time		Received	
SB2-15	Solid	P0504379-05		22 Apr. 05	9:45	25 Apr. 05 13:09	
Analyte(s)	Flag	Result	PQL	Units	Method #	Analysis Date	By
<b>WetChem</b>							
Acid Volatile Sulfide		0.94	0.12	% dry	WC43	7/8/05	rh
Chromium Extractable Sulfide		0.24	0.12	% dry	WC43	7/9/05	tld
Organic Carbon		18000	32	mg/Kg dry	3.2.13	4/26/05	rh
Strong Acid Divalent Manganese	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Strong Acid Ferric Iron	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Strong Acid Soluble Ferrous Iron		0.31	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Divalent Manganese	U	< 0.01	0.01	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferric Iron	U	< 0.01	0.01	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferrous Iron		0.12	0.01	% dry	WC43	7/8/05	md
<b>Organics/Prep</b>							
Percent Solids		78	1	%	160.3	4/27/05	jb

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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 Report Date: Draft  
 Client Proj Name: Altus AFB  
 Client Proj #: 735833.08000

Sample Description	Matrix	Lab Sample #		Sampled Date/Time		Received	
SB2-20	Solid	P0504379-06		22 Apr. 05	9:55	25 Apr. 05 13:09	
Analyte(s)	Flag	Result	PQL	Units	Method #	Analysis Date	By
<b>WetChem</b>							
Acid Volatile Sulfide		0.74	0.12	% dry	WC43	7/8/05	rh
Chromium Extractable Sulfide		0.82	0.12	% dry	WC43	7/9/05	tld
Organic Carbon		20000	32	mg/Kg dry	3.2.13	4/26/05	rh
Strong Acid Divalent Manganese	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Strong Acid Ferric Iron		0.09	0.02	% dry	WC43	7/8/05	md
Strong Acid Soluble Ferrous Iron		0.54	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Divalent Manganese	U	< 0.01	0.01	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferric Iron	U	< 0.01	0.01	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferrous Iron		0.31	0.01	% dry	WC43	7/8/05	md
<b>Organics/Prep</b>							
Percent Solids		78	1	%	160.3	4/27/05	jb

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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 Report Date: Draft  
 Client Proj Name: Altus AFB  
 Client Proj #: 735833.08000

Sample Description	Matrix	Lab Sample #		Sampled Date/Time		Received	
SB12-7	Solid	P0504379-07		22 Apr. 05	9:00	25 Apr. 05 13:09	
Analyte(s)	Flag	Result	PQL	Units	Method #	Analysis Date	By
<b>WetChem</b>							
Acid Volatile Sulfide		1.4	0.15	% dry	WC43	7/8/05	rh
Chromium Extractable Sulfide		1.2	0.15	% dry	WC43	7/9/05	tld
Organic Carbon		23000	37	mg/Kg dry	3.2.13	4/26/05	rh
Strong Acid Divalent Manganese	U	< 0.03	0.03	% dry	WC43	7/8/05	md
Strong Acid Ferric Iron		0.04	0.03	% dry	WC43	7/8/05	md
Strong Acid Soluble Ferrous Iron		0.18	0.03	% dry	WC43	7/8/05	md
Weak Acid Soluble Divalent Manganese		< 0.01	0.01	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferric Iron	U	< 0.01	0.01	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferrous Iron		0.06	0.01	% dry	WC43	7/8/05	md
<b>Organics/Prep</b>							
Percent Solids		67	1	%	160.3	4/27/05	jb

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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Report Date: Draft  
Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

**Prep Method:** Organic Carbon (Walkley-Black)  
**Analysis Method:** Organic Carbon (Walkley-Black)

**M050427011-MB**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>RDL</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
Organic Carbon	< 25.00 mg/Kg		25.00		- NA

**P0504379-04A-DUP**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
Organic Carbon	15000.00 mg/Kg			- NA	14.29	0 - 20

  Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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Report Date: Draft  
Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

**Prep Method:** Total Residue Gravimetric Dried at 103-105 degrees ce  
**Analysis Method:** Total Residue Gravimetric Dried at 103-105 degrees ce

There are no QC Samples in this Batch

  Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

**Prep Method:** Total Residue Gravimetric Dried at 103-105 degrees ce  
**Analysis Method:** Total Residue Gravimetric Dried at 103-105 degrees ce

There are no QC Samples in this Batch



Outlined Results Indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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Lab Proj #: P0504379  
Report Date: Draft  
Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

**Prep Method:** Chromium Extractable Sulfide  
**Analysis Method:** Chromium Extractable Sulfide

There are no QC Samples in this Batch

 Outlined Results Indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

**Prep Method:** Acid Volatile Sulfide  
**Analysis Method:** Acid Volatile Sulfide

M050713005-LCS

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
Acid Volatile Sulfide	28.60 %	32.90	87.00	50 - 150

Outlined Results Indicate results outside of Control limits

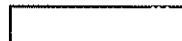
Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

**Prep Method:** Weak Acid Soluble Metals  
**Analysis Method:** Weak Acid Soluble Metals

There are no QC Samples in this Batch



Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

Client Name: Parsons Engineering Science  
Contact: Bruce Henry  
Address: 1700 Broadway  
Suite 900  
Denver, CO 80290

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Lab Proj #: P0504379  
Report Date: Draft  
Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

**Prep Method:** Strong Acid Soluble Metals  
**Analysis Method:** Strong Acid Soluble Metals

There are no QC Samples in this Batch

  Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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Address: 1700 Broadway  
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Denver, CO 80290

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Lab Proj #: P0504379  
Report Date: Draft  
Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

# PARSONS

1700 Broadway, Suite 900 • Denver, Colorado 80290 • (303) 831-8100 • Fax: (303) 831-8208 • [www.parsons.com](http://www.parsons.com)

August 31, 2005

Ms. Carmen Lebron  
NFESC ESC411  
1100 23<sup>rd</sup> Avenue  
Port Hueneme, CA 93043

Subject: Technical Memorandum: Bioavailable Iron Analytical Results for Subsurface Investigation of A Mulch Biowall at LF03, Altus Air Force Base, Oklahoma.

Dear Ms. Lebron:

Please find enclosed two copies of the subject technical memorandum. This technical memorandum was prepared by Parsons for the Naval Facilities Engineering Command, Port Hueneme, California. An electronic copy of the technical memorandum has been sent to you via email.

If you have any questions or comments on this deliverable, please call me at (970) 244-8829 or Mr. Bruce Henry at (303) 831-8100.

Sincerely,  
PARSONS

*John F. Hall, P.E.*

John F. Hall, P.E.  
Project Manager

cc: Mr. Bruce Henry, Parsons – (1 copy)  
Mr. Pat Evans, CDM – (1 copy)  
File: 735833.08000



## **TECHNICAL MEMORANDUM**

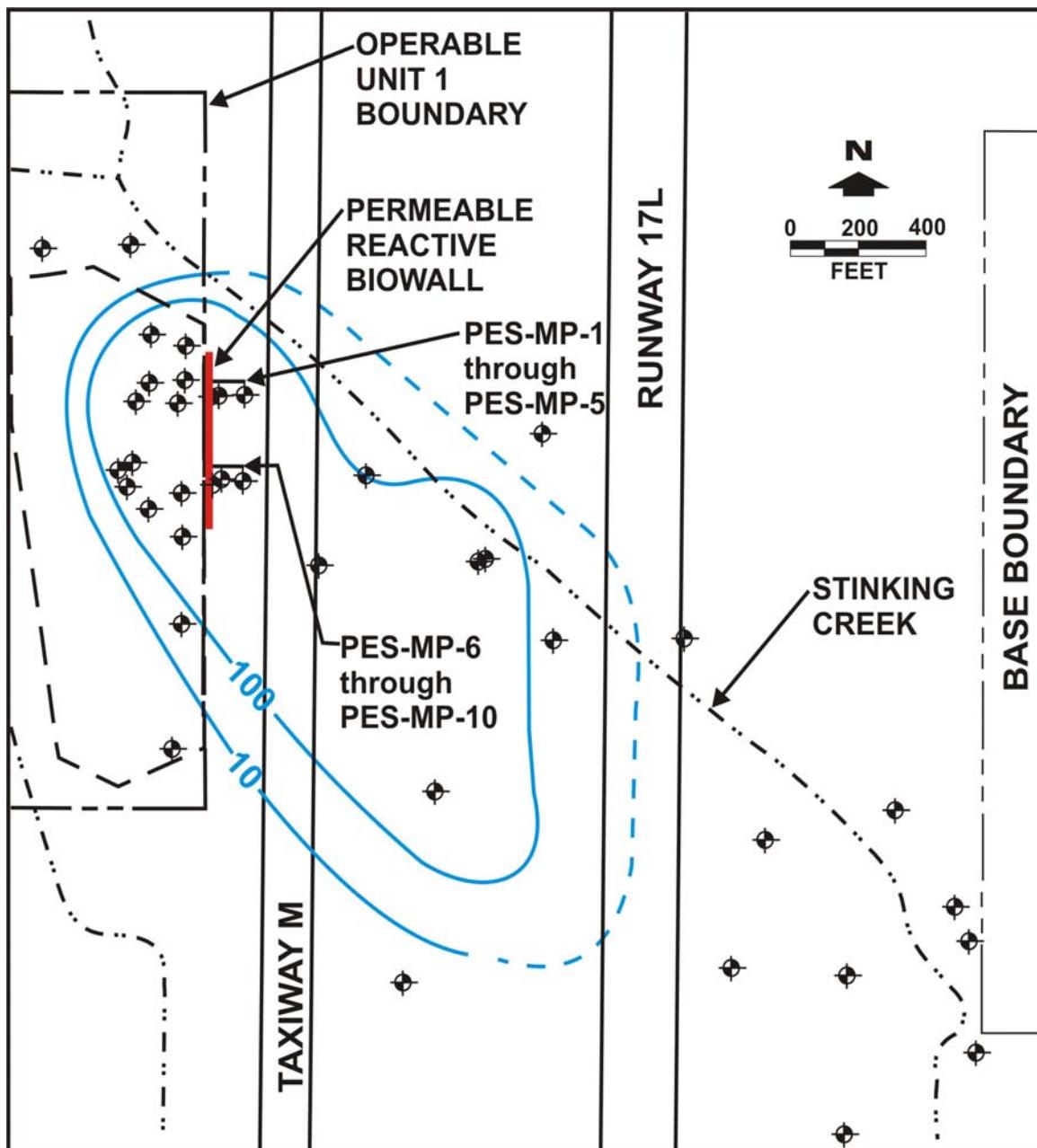
August 31, 2005

To: Ms. Carmen Labron  
From: John Hall, Parsons  
Subject: Bioavailable Iron Results, Altus Air Force Base, Oklahoma

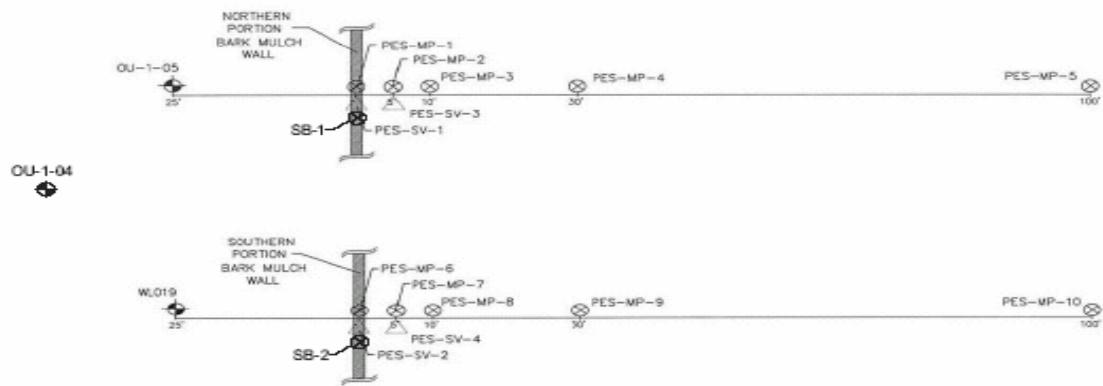
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This technical memorandum provides analytical results for bioavailable ferric iron and manganese in mulch biowall samples collected at Landfill 3 (LF03), Altus Air Force Base (AFB), Oklahoma. These results are an amendment to the report prepared by Parsons titled ***Subsurface Investigation of a Mulch Biowall at LF03, Altus Air Force Base, Oklahoma In Support of: Environmental Security Technology Certification Program Project CU-0316: Enhanced Bioremediation of cis-Dichloroethene (cis-DCE) and Vinyl Chloride (VC) Using Electron Shuttle, July 2005.***

The location of the mulch biowall and the sampling locations at LF-03 are shown on Figures 1 and 2, respectively (attached). Samples were collected on 22 April 2005. Sampling procedures are described in the above referenced report. Analytical results for bioavailable ferrous iron and bioavailable manganese are provided in the attached laboratory report and are summarized on Table 1 (attached).



**Figure 1. Location of Mulch Biowall Relative to TCE Plume (isoconcentration contours in micrograms per liter of TCE in April 1999. (CDM, 2004)**



**Figure 2. Monitoring Well Sampling Locations Relative to Mulch Biowall. (CDM, 2004)**

**TABLE 1**  
**SUMMARY OF SOIL/MULCH MINERALOGICAL RESULTS**  
**BIOAVAILABLE IRON AND MANGANESE**  
**LF03 MULCH BIOWALL**  
**ALTUS AFB, OKLAHOMA**

Sample Location	Sample Date	Sample Depth (feet bgs) <sup>a/</sup>	Percent Solids	B-AFe <sup>b/</sup> (mg/kg) <sup>c/</sup>	B-AMn <sup>b/</sup> (mg/kg)
SB1-5	22-Apr-05	5	60%	441	12.3
SB1-15	22-Apr-05	15	63%	622	10.0
SB1-20	22-Apr-05	20	64%	645	13.0
SB2-7	22-Apr-05	7	86%	290	<5.0 <sup>d/</sup>
SB12-7 (duplicate)	22-Apr-05	7	67%	13.6	<7.5
SB2-15	22-Apr-05	15	78%	182	7.2
SB2-20	22-Apr-05	20	78%	<6.4	<6.4

<sup>a/</sup> feet bgs = feet below ground surface.

<sup>b/</sup> B-AFe = bio-available ferric iron; B-AMn = bio-available manganese.

<sup>c/</sup> mg/kg = micrograms per kilogram dry weight.

<sup>d/</sup> <5.0 indicates that the analyte was not detected above the indicated method detection limit.



Client Name: Parsons Engineering Science  
Contact: Bruce Henry  
Address: 1700 Broadway  
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Page: Page 1 of 16  
Lab Proj #: P0504379  
Report Date: 08/17/05  
Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

## Laboratory Results

Lab Sample #	Client Sample ID
P0504379-01	SB1-5
P0504379-02	SB1-15
P0504379-03	SB1-20
P0504379-04	SB2-7
P0504379-05	SB2-15
P0504379-06	SB2-20
P0504379-07	SB12-7

Total pages in data package: 18

Microseeps test results meet all the requirements of the NELAC standards.

Approved By:

The analytical results reported here are reliable and usable to the precision expressed in this report. As required by some regulating authorities, a full discussion of the uncertainty in our analytical results can be obtained at our web site or through customer service. Unless otherwise specified, all results are reported on a wet weight basis.

*As a valued client we would appreciate your comments on our service.  
Please call customer service at (412)826-5245 or email [bhans@microseeps.com](mailto:bhans@microseeps.com)*

Case Narrative

Client Name: Parsons Engineering Science  
 Contact: Bruce Henry  
 Address: 1700 Broadway  
 Suite 900  
 Denver, CO 80290

Page: Page 2 of 16  
 Lab Proj #: P0504379  
 Report Date: 08/17/05  
 Client Proj Name: Altus AFB  
 Client Proj #: 735833.08000

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>		<u>Sampled Date/Time</u>		<u>Received</u>	
SB1-5	Solid	P0504379-01		22 Apr. 05	8:15	25 Apr. 05 13:09	
<u>Analyte(s)</u>	<u>Flag</u>	<u>Result</u>	<u>PQL</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>By</u>
<b>WetChem</b>							
Acid Volatile Sulfide		1.3	0.2	% dry	WC43	7/8/05	rh
Bio-Available Ferric Iron		441	8.3	mg/Kg dry	BAFellII	7/14/05	md
Bio-Available Manganese		12.3	8.3	mg/Kg dry	BAFellII	7/14/05	md
Chromium Extractable Sulfide		1.9	0.2	% dry	WC43	7/9/05	tld
Organic Carbon		29000	42	mg/Kg dry	3.2.13	4/26/05	rh
Oxidized Iron		27.0	8.3	mg/Kg dry	BAFellII	7/14/05	md
Strong Acid Divalent Manganese	U	< 0.03	0.03	% dry	WC43	7/8/05	md
Strong Acid Ferric Iron	U	< 0.03	0.03	% dry	WC43	7/8/05	md
Strong Acid Soluble Ferrous Iron		0.4	0.03	% dry	WC43	7/8/05	md
Weak Acid Soluble Divalent Manganese	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferric Iron	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferrous Iron		0.13	0.02	% dry	WC43	7/8/05	md
<b>Organics/Prep</b>							
Percent Solids		60	1.0	%	160.3	4/27/05	jb

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

Client Name: Parsons Engineering Science  
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 Lab Proj #: P0504379  
 Report Date: 08/17/05  
 Client Proj Name: Altus AFB  
 Client Proj #: 735833.08000

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>			<u>Sampled Date/Time</u>	<u>Received</u>	
SB1-15	Solid	P0504379-02			22 Apr. 05 8:30	25 Apr. 05 13:09	
<u>Analyte(s)</u>	<u>Flag</u>	<u>Result</u>	<u>PQL</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>By</u>
<b>WetChem</b>							
Acid Volatile Sulfide		1.3	0.2	% dry	WC43	7/8/05	rh
Bio-Available Ferric Iron		622	7.9	mg/Kg dry	BAFeIII	7/14/05	md
Bio-Available Manganese		10.0	7.9	mg/Kg dry	BAFeIII	7/14/05	md
Chromium Extractable Sulfide		1.0	0.2	% dry	WC43	7/9/05	tld
Organic Carbon		41000	40	mg/Kg dry	3.2.13	4/26/05	rh
Oxidized Iron		46.3	7.9	mg/Kg dry	BAFeIII	7/14/05	md
Strong Acid Divalent Manganese	U	< 0.03	0.03	% dry	WC43	7/8/05	md
Strong Acid Ferric Iron		0.03	0.03	% dry	WC43	7/8/05	md
Strong Acid Soluble Ferrous Iron		0.5	0	% dry	WC43	7/8/05	md
Weak Acid Soluble Divalent Manganese	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferric Iron	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferrous Iron		0.20	0.02	% dry	WC43	7/8/05	md
<b>Organics/Prep</b>							
Percent Solids		63	1.0	%	160.3	4/27/05	jb

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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 Lab Proj #: P0504379  
 Report Date: 08/17/05  
 Client Proj Name: Altus AFB  
 Client Proj #: 735833.08000

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>			<u>Sampled Date/Time</u>		<u>Received</u>
SB1-20	Solid	P0504379-03			22 Apr. 05	8:40	25 Apr. 05 13:09
<u>Analyte(s)</u>	<u>Flag</u>	<u>Result</u>	<u>PQL</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>By</u>
<b>WetChem</b>							
Acid Volatile Sulfide		0.7	0.2	% dry	WC43	7/8/05	rh
Bio-Available Ferric Iron		645.0	7.8	mg/Kg dry	BAFellII	7/14/05	md
Bio-Available Manganese		13.0	7.8	mg/Kg dry	BAFellII	7/14/05	md
Chromium Extractable Sulfide		0.8	0.2	% dry	WC43	7/9/05	tld
Organic Carbon		21000.00	39.00	mg/Kg dry	3.2.13	4/26/05	rh
Oxidized Iron		22.0	7.8	mg/Kg dry	BAFellII	7/14/05	md
Strong Acid Divalent Manganese	U	< 0.03	0.03	% dry	WC43	7/8/05	md
Strong Acid Ferric Iron	U	< 0.03	0.03	% dry	WC43	7/8/05	md
Strong Acid Soluble Ferrous Iron	U	0.05	0.03	% dry	WC43	7/8/05	md
Weak Acid Soluble Divalent Manganese	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferric Iron	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferrous Iron	U	< 0.02	0.02	% dry	WC43	7/8/05	md
<b>Organics/Prep</b>							
Percent Solids		64	1.0	%	160.3	4/27/05	jb

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

Client Name: Parsons Engineering Science  
 Contact: Bruce Henry  
 Address: 1700 Broadway  
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 Denver, CO 80290

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 Lab Proj #: P0504379  
 Report Date: 08/17/05  
 Client Proj Name: Altus AFB  
 Client Proj #: 735833.08000

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>			<u>Sampled Date/Time</u>	<u>Received</u>	
SB2-7	Solid	P0504379-04			22 Apr. 05 9:40	25 Apr. 05 13:09	
<u>Analyte(s)</u>	<u>Flag</u>	<u>Result</u>	<u>PQL</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>By</u>
<b>WetChem</b>							
Acid Volatile Sulfide		0.9	0.1	% dry	WC43	7/8/05	rh
Bio-Available Ferric Iron		290.0	5.8	mg/Kg dry	BAFelll	7/14/05	md
Bio-Available Manganese	U	< 5.0	5.8	mg/Kg dry	BAFelll	7/14/05	md
Chromium Extractable Sulfide		0.6	0.1	% dry	WC43	7/9/05	tld
Organic Carbon		15000.00	29.00	mg/Kg dry	3.2.13	4/26/05	rh
Oxidized Iron		10.1	5.8	mg/Kg dry	BAFelll	7/14/05	md
Strong Acid Divalent Manganese	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Strong Acid Ferric Iron	U	0.02	0.02	% dry	WC43	7/8/05	md
Strong Acid Soluble Ferrous Iron		0.1	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Divalent Manganese	U	< 0.01	0.01	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferric Iron	U	< 0.01	0.01	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferrous Iron	U	< 0.03	0.01	% dry	WC43	7/8/05	md
<b>OrganicsPrep</b>							
Percent Solids		86	1	%	160.3	4/27/05	jb

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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Page: Page 6 of 16  
 Lab Proj #: P0504379  
 Report Date: 08/17/05  
 Client Proj Name: Altus AFB  
 Client Proj #: 735833.08000

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>			<u>Sampled Date/Time</u>		<u>Received</u>
SB2-15	Solid	P0504379-05			22 Apr. 05 9:45		25 Apr. 05 13:09
<u>Analyte(s)</u>	<u>Flag</u>	<u>Result</u>	<u>PQL</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>By</u>
<b>WetChem</b>							
Acid Volatile Sulfide		0.9	0.1	% dry	WC43	7/8/05	rh
Bio-Available Ferric Iron		182.0	6.4	mg/Kg dry	BAFelll	7/14/05	md
Bio-Available Manganese		7.2	6.4	mg/Kg dry	BAFelll	7/14/05	md
Chromium Extractable Sulfide		0.2	0.1	% dry	WC43	7/9/05	tld
Organic Carbon		18000.00	32.00	mg/Kg dry	3.2.13	4/26/05	rh
Oxidized Iron		19.0	6.4	mg/Kg dry	BAFelll	7/14/05	md
Strong Acid Divalent Manganese	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Strong Acid Ferric Iron	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Strong Acid Soluble Ferrous Iron		0.3	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Divalent Manganese	U	< 0.01	0.01	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferric Iron	U	< 0.01	0.01	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferrous Iron		0.1	0.01	% dry	WC43	7/8/05	md
<b>Organics/Prep</b>							
Percent Solids		78	1	%	160.3	4/27/05	jb

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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 Report Date: 08/17/05  
 Client Proj Name: Altus AFB  
 Client Proj #: 735833.08000

<u>Sample Description</u>	<u>Matrix</u>	<u>Lab Sample #</u>		<u>Sampled Date/Time</u>		<u>Received</u>	
SB2-20	Solid	P0504379-06		22 Apr. 05 9:55		25 Apr. 05 13:09	
<u>Analyte(s)</u>	<u>Flag</u>	<u>Result</u>	<u>PQL</u>	<u>Units</u>	<u>Method #</u>	<u>Analysis Date</u>	<u>By</u>
<b>WetChem</b>							
Acid Volatile Sulfide		0.7	0.1	% dry	WC43	7/8/05	rh
Bio-Available Ferric Iron	U	< 6.4	6.4	mg/Kg dry	BAFelll	7/14/05	md
Bio-Available Manganese		< 6.4	6.4	mg/Kg dry	BAFelll	7/14/05	md
Chromium Extractable Sulfide		0.8	0.1	% dry	WC43	7/9/05	tld
Organic Carbon		20000.00	32.00	mg/Kg dry	3.2.13	4/26/05	rh
Oxidized Iron		123	6.4	mg/Kg dry	BAFelll	7/14/05	md
Strong Acid Divalent Manganese	U	< 0.02	0.02	% dry	WC43	7/8/05	md
Strong Acid Ferric Iron		0.1	0.02	% dry	WC43	7/8/05	md
Strong Acid Soluble Ferrous Iron		0.5	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Divalent Manganese		0.01	0.01	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferric Iron		0.01	0.01	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferrous Iron		0.3	0.01	% dry	WC43	7/8/05	md
<b>OrganicsPrep</b>							
Percent Solids		78	1	%	160.3	4/27/05	jb

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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Page: Page 8 of 16  
 Lab Proj #: P0504379  
 Report Date: 08/17/05  
 Client Proj Name: Altus AFB  
 Client Proj #: 735833.08000

Sample Description	Matrix	Lab Sample #		Sampled Date/Time		Received	
SB12-7	Solid	P0504379-07		22 Apr. 05 9:00		25 Apr. 05 13:09	
Analyte(s)	Flag	Result	PQL	Units	Method #	Analysis Date	By
<b>WetChem</b>							
Acid Volatile Sulfide		1.4	0.1	% dry	WC43	7/8/05	rh
Bio-Available Ferric Iron		13.6	7.5	mg/Kg dry	BAFelll	7/14/05	md
Bio-Available Manganese		< 7.5	7.5	mg/Kg dry	BAFelll	7/14/05	md
Chromium Extractable Sulfide		1.2	0.1	% dry	WC43	7/9/05	tld
Organic Carbon		23000.00	37.00	mg/Kg dry	3.2.13	4/26/05	rh
Oxidized Iron	J	5.1	7.5	mg/Kg dry	BAFelll	7/14/05	md
Strong Acid Divalent Manganese	U	< 0.03	0.03	% dry	WC43	7/8/05	md
Strong Acid Ferric Iron		0.04	0.03	% dry	WC43	7/8/05	md
Strong Acid Soluble Ferrous Iron		0.2	0.02	% dry	WC43	7/8/05	md
Weak Acid Soluble Divalent Manganese	J	< 0.01	0.01	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferric Iron	U	< 0.01	0.01	% dry	WC43	7/8/05	md
Weak Acid Soluble Ferrous Iron		0.1	0	% dry	WC43	7/8/05	md
<b>OrganicsPrep</b>							
Percent Solids		67	1	%	160.3	4/27/05	jb

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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Page: Page 9 of 16  
Lab Proj #: P0504379  
Report Date: 08/17/05  
Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

**Prep Method:** Organic Carbon (Walkley-Black)  
**Analysis Method:** Organic Carbon (Walkley-Black)

**M050427011-MB**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>RDL</u>	<u>%Recovery</u>	<u>Ctl Limits</u>		
Organic Carbon	< 25.00 mg/Kg		25.00		- NA		
<b>P0504379-04A-DUP</b>							
Organic Carbon	15000.00 mg/Kg				- NA	14.29	0 - 20

Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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Page: Page 10 of 16  
Lab Proj #: P0504379  
Report Date: 08/17/05  
Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

**Prep Method:** Total Residue Gravimetric Dried at 103-105 degrees c  
**Analysis Method:** Total Residue Gravimetric Dried at 103-105 degrees c

There are no QC Samples in this Batch

Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

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Lab Proj #: P0504379  
Report Date: 08/17/05  
Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

**Prep Method:** Total Residue Gravimetric Dried at 103-105 degrees c  
**Analysis Method:** Total Residue Gravimetric Dried at 103-105 degrees c

There are no QC Samples in this Batch

Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

Client Name: Parsons Engineering Science  
Contact: Bruce Henry  
Address: 1700 Broadway  
Suite 900  
Denver, CO 80290

Page: Page 12 of 16  
Lab Proj #: P0504379  
Report Date: 08/17/05  
Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

**Prep Method:** Chromium Extractable Sulfide  
**Analysis Method:** Chromium Extractable Sulfide

There are no QC Samples in this Batch

Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

Client Name: Parsons Engineering Science  
Contact: Bruce Henry  
Address: 1700 Broadway  
Suite 900  
Denver, CO 80290

Page: Page 13 of 16  
Lab Proj #: P0504379  
Report Date: 08/17/05  
Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

**Prep Method:** Acid Volatile Sulfide  
**Analysis Method:** Acid Volatile Sulfide

M050713005-LCS

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
Acid Volatile Sulfide	28.60 %	32.90	87.00	50 - 150

Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

Client Name: Parsons Engineering Science  
Contact: Bruce Henry  
Address: 1700 Broadway  
Suite 900  
Denver, CO 80290

Page: Page 14 of 16  
Lab Proj #: P0504379  
Report Date: 08/17/05  
Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

**Prep Method:** Weak Acid Soluble Metals  
**Analysis Method:** Weak Acid Soluble Metals

There are no QC Samples in this Batch

Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

Client Name: Parsons Engineering Science  
Contact: Bruce Henry  
Address: 1700 Broadway  
Suite 900  
Denver, CO 80290

Page: Page 15 of 16  
Lab Proj #: P0504379  
Report Date: 08/17/05  
Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

**Prep Method:** Strong Acid Soluble Metals  
**Analysis Method:** Strong Acid Soluble Metals

There are no QC Samples in this Batch

Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

Client Name: Parsons Engineering Science  
Contact: Bruce Henry  
Address: 1700 Broadway  
Suite 900  
Denver, CO 80290

Page: Page 16 of 16  
Lab Proj #: P0504379  
Report Date: 08/17/05  
Client Proj Name: Altus AFB  
Client Proj #: 735833.08000

**Prep Method:** BioAvailable Ferric Iron  
**Analysis Method:** BioAvailable Ferric Iron

**M050817023-MB**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>RDL</u>	<u>%Recovery</u>	<u>Ctl Limits</u>
Bio-Available Ferric Iron	56.6	mg/Kg	5.0		- NA
Bio-Available Manganese	18.2	mg/Kg	5.0		- NA
Oxidized Iron	< 5.0	mg/Kg	5.0		- NA

**P0504379-04A-DUP**

	<u>Result</u>	<u>TrueSpikeConc.</u>	<u>%Recovery</u>	<u>Ctl Limits</u>	<u>RPD</u>	<u>RPD Ctl Limits</u>
Bio-Available Ferric Iron	254.0	mg/Kg		- NA	1.59	0 - 30
Bio-Available Manganese	< 5.0	mg/Kg		- NA	0	0 - 30
Oxidized Iron	< 5.0	mg/Kg		- NA	0.00	0 - 30

  Outlined Results indicate results outside of Control limits

Data Qualifiers: J - estimated value, U - Non detect, R - Poor surrogate recovery, M - Recovery/RPD poor for MS/MSD, SAMP/DUP, B - detected in blank, S - field sample as received did not meet NELAC sample acceptance criteria, L - Subcontracted Lab used, N - NELAC certified analysis

Dry Ice

638 D

POS04379

**CHAIN - OF - CUSTODY RECORD**

Phone: (412) 826-5245

Microseeps, Inc. - 220 William Pitt Way - Pittsburgh, PA 15238

Fax No. : (412) 826-3433

**Company :**

Parsons

Co. Address :

1700 Broadway Denver Co 80287

Proj. Manager:

John Hall / Bruce Henry

**Proj. Location:**

Altus AF6

Phone # :

303 831 8100

Fax # : 303 831 8208

Sampler's signature :

John W. Weller

Relinquished by : <i>J. W. B.</i>	Company : <i>Parsons</i>	Date : <i>4/22/05</i>	Time : <i>1500</i>	Received by : <i>John</i>	Company : <i>W. M. S.</i>	Date : <i>4/22/05</i>	Time : <i>1500</i>
Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :
Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :



## **Appendix C**

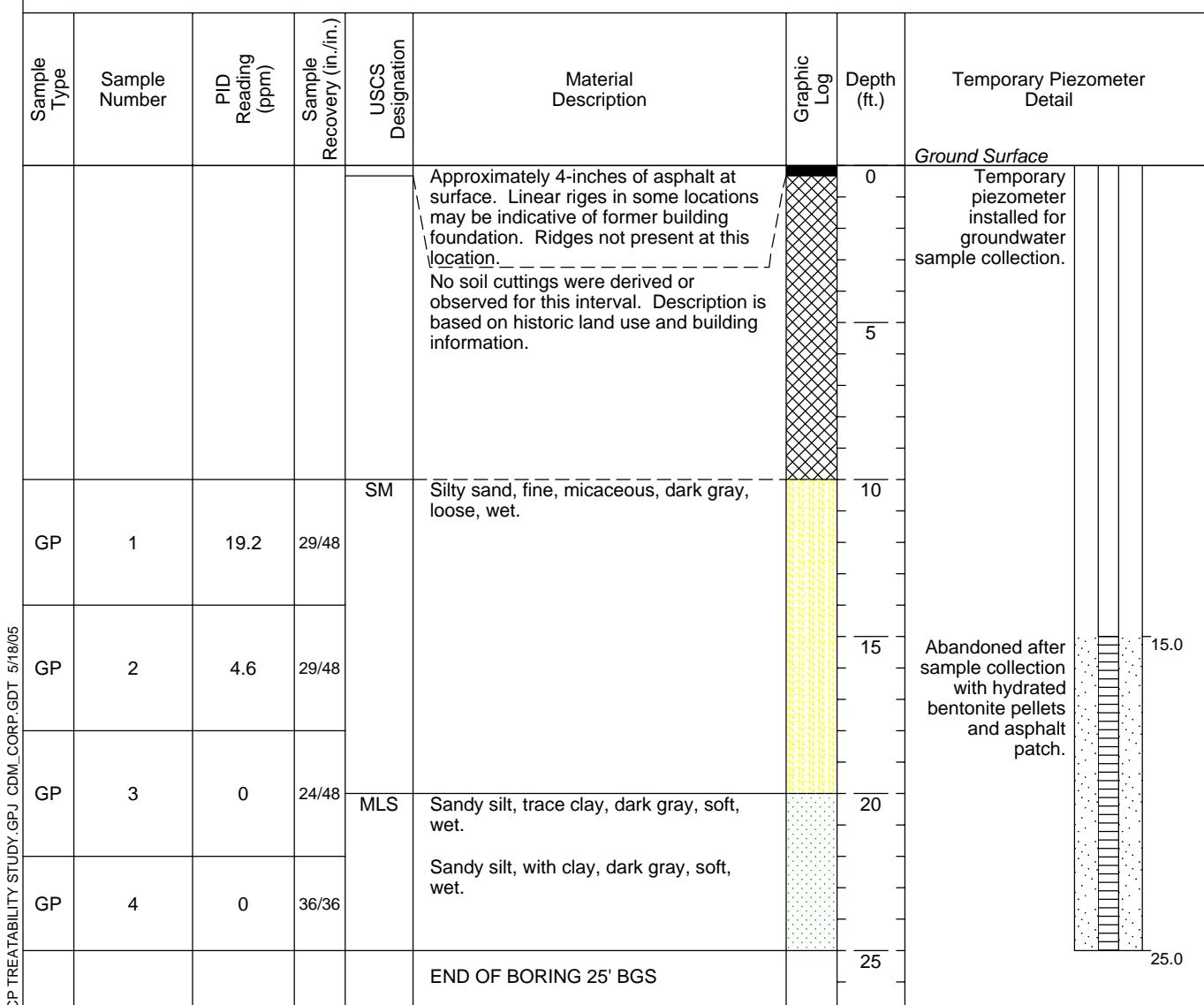
### **Commercial Sources of Electron Shuttles**

**Table C1****Commercial Electron Shuttle Product Sources**

Supplier	Contact	Phone	Product	Form	Humic Acid	Fulvic Acid	Source
TeraVita	Erik Morgan/Eric Danese	717 291 7251 x202	SP-85	85% soluble solid	80	5	Leonardite
TeraVita	Erik Morgan/Eric Danese	717 291 7251 x202	SP-100	100% soluble solid	95	5	Leonardite
Earth Green Products	Cindy Brooks/John Lown	214 750 4698	Grow-Plex SP	100% soluble solid	60	26	Menefee (freshwater)
Luscar Ltd	Edwin Liem	780 453 2100	Dry Soluble 80	100% soluble solid	38	17	Subbituminous coal
Luscar Ltd	Edwin Liem	780 453 2100	Liquid 12000	12% Liquid	8.3	3.7	Subbituminous coal
Triad	Jason Daley	209 527 0607	Huma K	100% soluble solid	56	30	Leonardite
Live Earth Products	Russell Taylor	435 286 2222	12% Liquid Humic Acid	12% Liquid	10	2	Humic shale
Live Earth Products	Russell Taylor	435 286 2222	6% Liquid Humic Acid	6% Liquid	5	1	Humic shale
Monterey AgResources	Jim Tuttle	559 499 2100	HA-12	12% Liquid	9	3	Leonardite
Humate International	Brian Galbraith/Albert LeBlanc	800 393 4769	Humate AS	100% soluble solid	75	25	Leonardite
Humus Products of America	Basil Panas	281 341 5045	12% Concentrated Liquid Humus	12% Liquid	12	<- ?	Leonardite
Humus Products of America	Basil Panas	281 341 5045	15% Concentrated Liquid Humus	15% Liquid	15	<- ?	Leonardite
LignoTech	Ron Pena/Stu Lebo	602 418 9818/715 355 3628	BorreGro HA-2	100% soluble solid	50	20	Leonardite
LignoTech	Ron Pena/Stu Lebo	602 418 9818/715 355 3628	BorreGro HA-1	100% soluble solid	50	20	Modified leonardite
Horizon Ag Products	Oscar Boyce/Ken Day	509 736 0951	Quantum H	7% Liquid	6.9	0.1	Leonardite
Horizon Ag Products	Oscar Boyce/Ken Day	509 736 0951	Fulvic 6000	0.18% Liquid	0	0.18	Leonardite
UAS America	Mark Pecsenka	727 861 7710 x101	Super Hume	17% Liquid	3	14	Leonardite
Northwest Agricultural Products	Kyle Hartmier	509 547 8234	Ful-Vac 3	3% Liquid	0	3	Leonardite
Natural Resources Group	John Andreas	559 564 1236	Power FA	Solid	0	75	Leonardite
Natural Resources Group	John Andreas	559 564 1236	F Power 10%	10% Liquid	0	10	Leonardite
Humatech	David Williams	800 729 0898	Aqua F	Liquid	0	3	

## **Appendix D**

## **Soil Boring Logs**

**BORING LOG and  
PIEZOMETER DETAIL  
11GP24****Client:** Naval Facilities Engineering Service Center**Project Name:** ESTCP Treatability Study**Project Location:** SPAWAR OTC IR Site 11, San Diego, CA **Project Number:** 6215.001**Drilling Contractor:** HP Labs**Total Depth (ft.):** 25**Drilling Method/Rig:** Direct Push/Geoprobe**Depth to Initial Water Level (ft. BGS):** 12.14**Drillers:** K. Schindler, A. Garcia**Abandonment Method:** hydrated bentonite, asphalt patch**Drilling Date:** **Start:** 5-3-05 **End:** 5-3-05**Field Screening Instrument:** PID**Logged By:** Holly Carter**EXPLANATION OF ABBREVIATIONS****DRILLING METHODS:**

HSA - Hollow Stem Auger  
SSA - Solid Stem Auger  
HA - Hand Auger  
AR - Air Rotary  
MR - Mud Rotary  
DP - Direct Push

**SAMPLING TYPES:**

SH - Slide Hammer  
GP - Geoprobe  
SS - Split Spoon

**OTHER:**

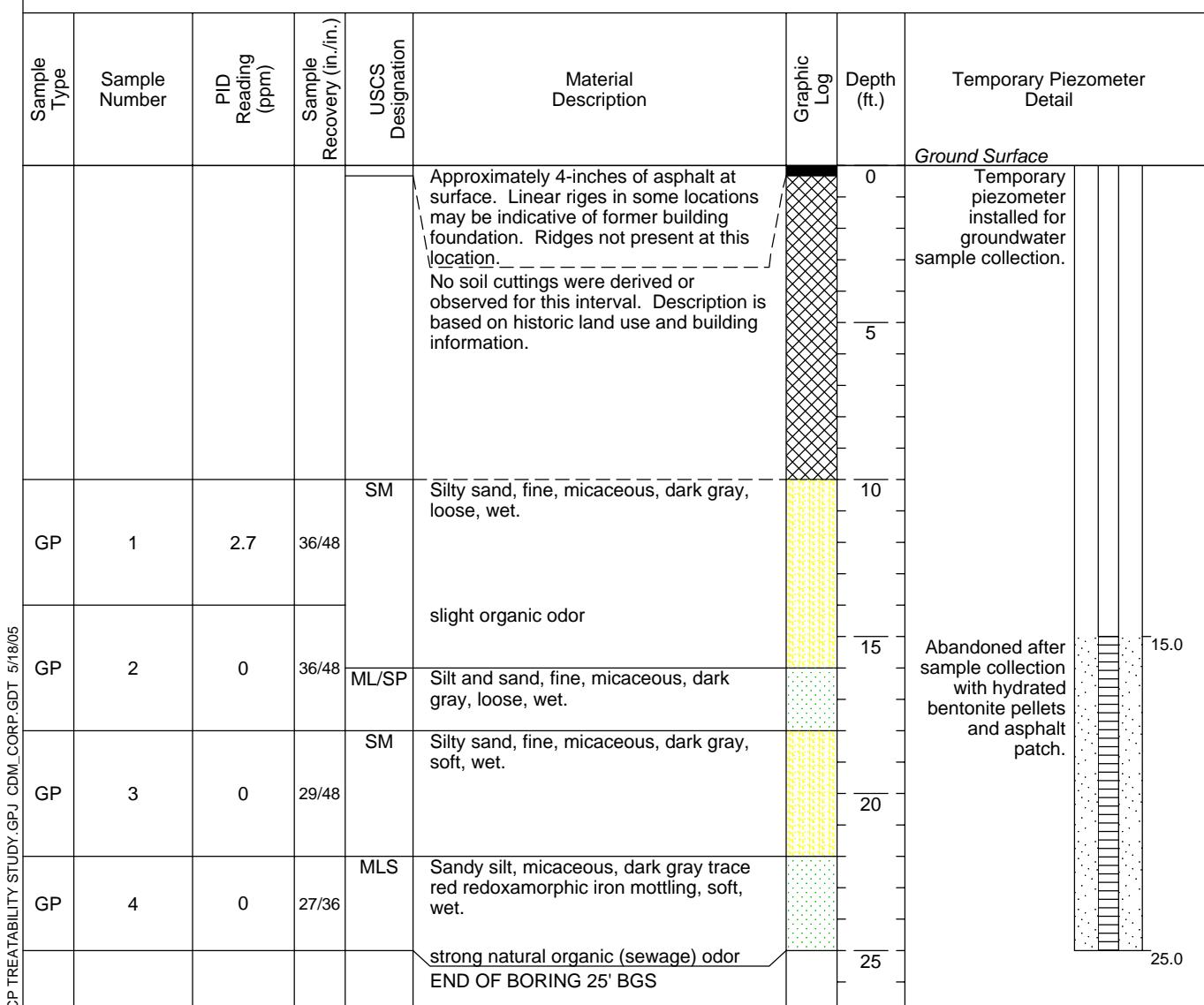
BGS - Below Ground Surface  
BZ - Breathing Zone  
BH - Borehole  
S - Sample Head Space  
NR - No Reading/Not Recorded  
NA - Not Applicable  
PID - photo-ionization detector  
ppm - parts per million

Collected composite soil sample 11GP24 (10-20') at 1155 for APCL analyses: 6010B/3050B (As, Fe, Mn, V) and SW960. Additional soil samples were submitted to CDM in Bellevue, WA and the USGS for analyses to be chosen.

Collected groundwater sample 11GP24 and 11GP24dup at 1438 and 1445 for APCL analyses: 8260B/5030B, 6010B/3010A, CA 8015 modified, 300.0, 160.1, 376.1, RSK-175, and 415.1.

**REMARKS**

Reviewed by: \_\_\_\_\_ Date: \_\_\_\_\_

**BORING LOG and  
PIEZOMETER DETAIL  
11GP25****Client:** Naval Facilities Engineering Service Center**Project Name:** ESTCP Treatability Study**Project Location:** SPAWAR OTC IR Site 11, San Diego, CA **Project Number:** 6215.001**Drilling Contractor:** HP Labs**Total Depth (ft.):** 25**Drilling Method/Rig:** Direct Push/Geoprobe**Depth to Initial Water Level (ft. BGS):** 12.10**Drillers:** K. Schindler, A. Garcia**Abandonment Method:** hydrated bentonite, asphalt patch**Drilling Date:** **Start:** 5-3-05 **End:** 5-3-05**Field Screening Instrument:** PID**Logged By:** Holly Carter**EXPLANATION OF ABBREVIATIONS****DRILLING METHODS:**

HSA - Hollow Stem Auger  
SSA - Solid Stem Auger  
HA - Hand Auger  
AR - Air Rotary  
MR - Mud Rotary  
DP - Direct Push

**SAMPLING TYPES:**

SH - Slide Hammer  
GP - Geoprobe  
SS - Split Spoon

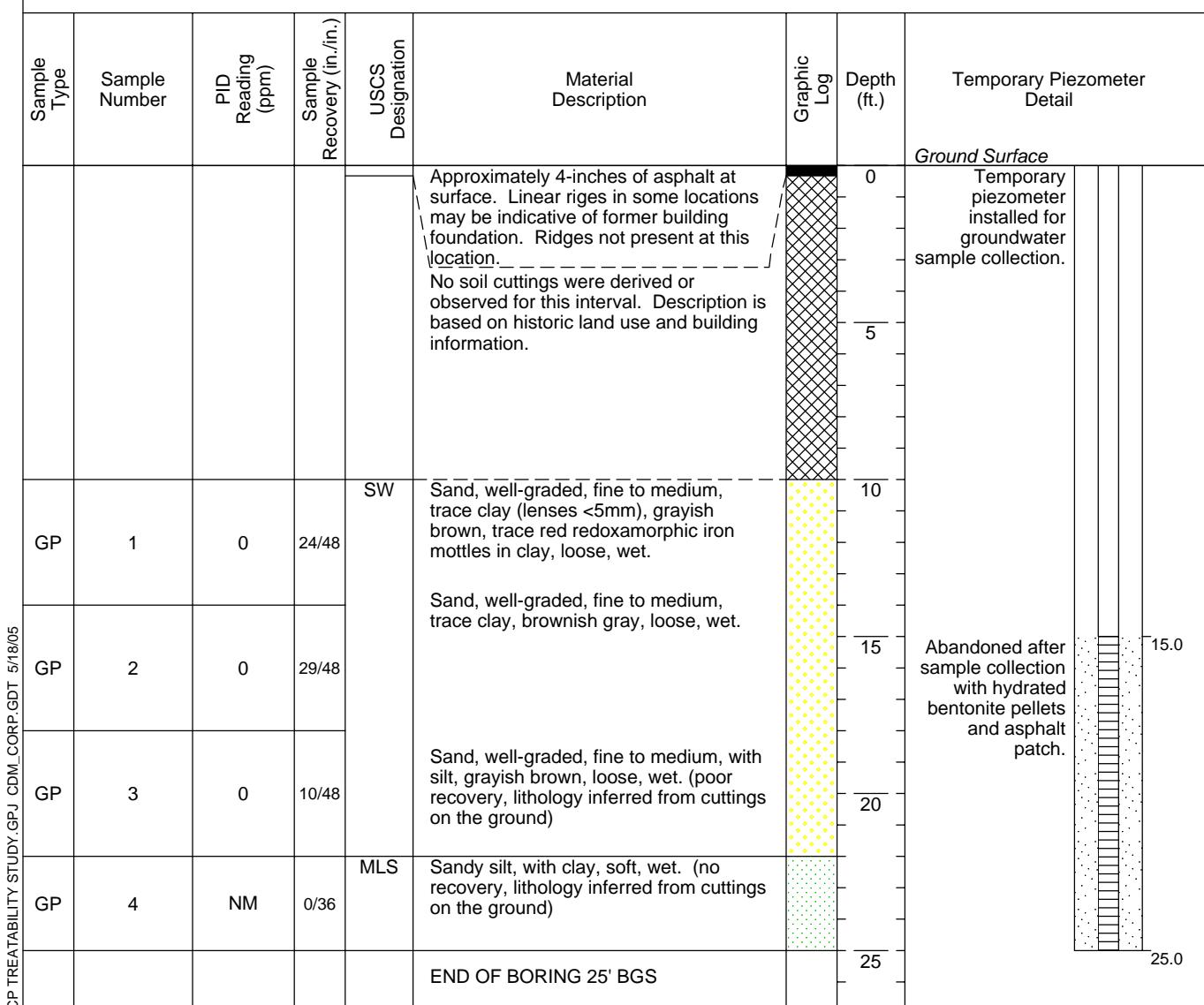
**OTHER:**

BGS - Below Ground Surface  
BZ - Breathing Zone  
BH - Borehole  
S - Sample Head Space  
NR - No Reading/Not Recorded  
NA - Not Applicable  
PID - photo-ionization detector  
ppm - parts per million

Collected composite soil sample 11GP25 (10-22') at 1035 for APCL analyses: 6010B/3050B (As, Fe, Mn, V) and SW960. Additional soil samples were submitted to CDM in Bellevue, WA and the USGS for analyses to be chosen.

Collected groundwater sample 11GP25 at 1336 for APCL analyses: 8260B/5030B, 6010B/3010A, CA 8015 modified, 300.0, 160.1, 376.1, RSK-175, and 415.1.

**REMARKS****Reviewed by:****Date:**

**BORING LOG and  
PIEZOMETER DETAIL  
11GP26****Client:** Naval Facilities Engineering Service Center**Project Name:** ESTCP Treatability Study**Project Location:** SPAWAR OTC IR Site 11, San Diego, CA **Project Number:** 6215.001**Drilling Contractor:** HP Labs**Total Depth (ft.):** 25**Drilling Method/Rig:** Direct Push/Geoprobe**Depth to Initial Water Level (ft. BGS):** 12.56**Drillers:** K. Schindler, A. Garcia**Abandonment Method:** hydrated bentonite, asphalt patch**Drilling Date:** **Start:** 5-3-05 **End:** 5-3-05**Field Screening Instrument:** PID**Logged By:** Holly Carter**EXPLANATION OF ABBREVIATIONS****DRILLING METHODS:**

HSA - Hollow Stem Auger  
SSA - Solid Stem Auger  
HA - Hand Auger  
AR - Air Rotary  
MR - Mud Rotary  
DP - Direct Push

**SAMPLING TYPES:**

SH - Slide Hammer  
GP - Geoprobe  
SS - Split Spoon

**OTHER:**

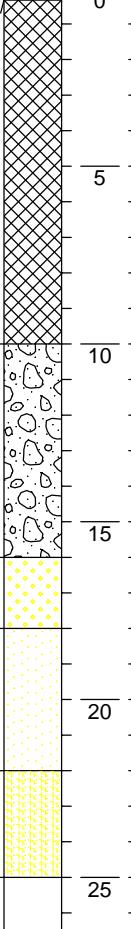
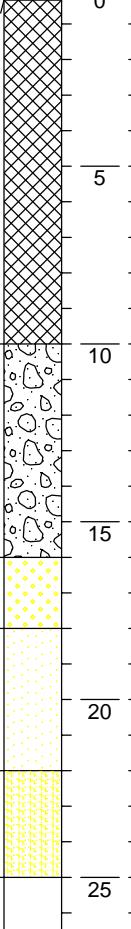
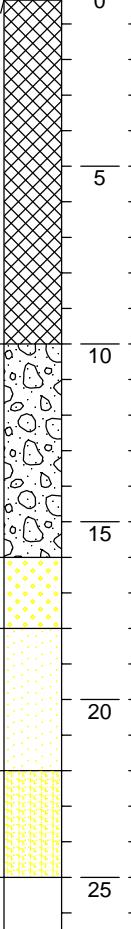
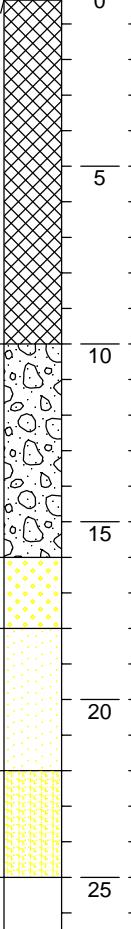
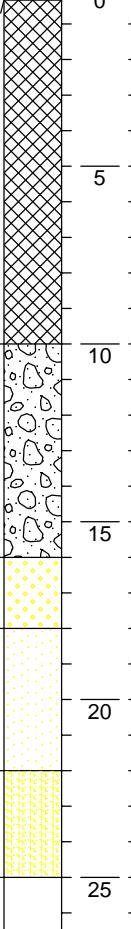
BGS - Below Ground Surface  
BZ - Breathing Zone  
BH - Borehole  
S - Sample Head Space  
NR - No Reading/Not Recorded  
NA - Not Applicable  
PID - photo-ionization detector  
ppm - parts per million

Collected composite soil sample 11GP26 (10-22') at 1340 for APCL analyses: 6010B/3050B (As, Fe, Mn, V) and SW960. Additional soil samples were submitted to CDM in Bellevue, WA and the USGS for analyses to be chosen.

Collected groundwater sample 11GP26 at 1553 for APCL analyses: 8260B/5030B, 6010B/3010A, CA 8015 modified, 300.0, 160.1, 376.1, RSK-175, and 415.1.

**REMARKS****Reviewed by:****Date:**

**BORING LOG and  
PIEZOMETER DETAIL  
11GP27****Client:** Naval Facilities Engineering Service Center**Project Name:** ESTCP Treatability Study**Project Location:** SPAWAR OTC IR Site 11, San Diego, CA **Project Number:** 6215.001**Drilling Contractor:** HP Labs**Total Depth (ft.):** 25**Drilling Method/Rig:** Direct Push/Geoprobe**Depth to Initial Water Level (ft. BGS):** 12.67**Drillers:** K. Schindler, A. Garcia**Abandonment Method:** hydrated bentonite, asphalt patch**Drilling Date:** **Start:** 5-3-05 **End:** 5-3-05**Field Screening Instrument:** PID**Logged By:** Holly Carter

Sample Type	Sample Number	PID Reading (ppm)	Sample Recovery (in./in.)	USCS Designation	Material Description	Graphic Log	Depth (ft.)	Temporary Piezometer Detail	
					Approximately 4-inches of asphalt at surface. Linear ripples in some locations may be indicative of former building foundation. Ridges not present at this location.  No soil cuttings were derived or observed for this interval. Description is based on historic land use and building information.		0 5 10 15 20 25	Temporary piezometer installed for groundwater sample collection.	
GP	1	NM	3/48	GS	Sandy gravel, poorly-graded, fine, subrounded to subangular gravel, fine to medium sand, with clay, brown, wet.		10 15 20 25		
GP	2	0	24/48	SW	Sand, well-graded, fine to medium, trace gravel, fine, subrounded to subangular, grayish brown, loose, wet.		15 20 25	Abandoned after sample collection with hydrated bentonite pellets and asphalt patch.	15.0
GP	3	0	20/48	SP	Sand, poorly-graded, fine to medium, gray, loose, wet.		20 25		
GP	4	0	36/36	SM	Silty sand, fine to medium, micaceous, gray, loose, wet.		36 48		
END OF BORING 25' BGS									

SPAWAR ESTCP FINAL SPAWAR ESTCP TREATABILITY STUDY.GPJ CDM\_CORP.GDT 5/18/05

**EXPLANATION OF ABBREVIATIONS**

HSA - Hollow Stem Auger  
SSA - Solid Stem Auger  
HA - Hand Auger  
AR - Air Rotary  
MR - Mud Rotary  
DP - Direct Push

**SAMPLING TYPES:**

SH - Slide Hammer  
GP - Geoprobe  
SS - Split Spoon

**OTHER:**

BGS - Below Ground Surface  
BZ - Breathing Zone  
BH - Borehole  
S - Sample Head Space  
NR - No Reading/Not Recorded  
NA - Not Applicable  
PID - photo-ionization detector  
ppm - parts per million

Collected composite soil sample 11GP27 (14-22') and 11GP27 (14-22')dup at 1500 for APCL analyses: 6010B/3050B (As, Fe, Mn, V) and SW960. Additional soil samples were submitted to CDM in Bellevue, WA and the USGS for analyses to be chosen.

Collected groundwater sample 11GP27 at 1825 for APCL analyses: 8260B/5030B, 6010B/3010A, CA 8015 modified, 300.0, 160.1, 376.1, RSK-175, and 415.1.

**REMARKS****Reviewed by:****Date:**

## **Appendix E**

## **Analytical Data**

# Applied P & CH Laboratories

13760 Magnolia Ave., Chino, CA 91710

Tel: (909) 590-1828 Fax: (909) 590-1498

Submitted to:

CDM Federal Programs Corp.

Attention: Michael Allen

9444 Farnham Street, Ste 210

San Diego CA 92123

Tel: (858)268-3383 Fax: (858)268-9677

# APCL Analytical Report

Service ID #: 801-052580

Received: 05/04/05

Collected by:

Extracted: N/A

Collected on: 05/03/05

Tested: 05/05-12/05

Reported: 05/20/05

Sample Description: Soil and Water

Project Description: 6215.001 SPAWAR ESTCP.

## Analysis of Water and Soil Samples

### I . Analysis of Water Samples

Component Analyzed	Method	Unit	PQL	Analysis Result		
				11GP24 05-02580-1	11GP25 05-02580-2	11GP26 05-02580-3
BROMIDE	320.1	mg/L	1	7.1	10.8	7.8
HARDNESS	130.2	mg/L	3	765	1,100	895
NITRATE AS N	353.3	mg/L	0.1	0.14	0.068J	<0.1
NITRITE AS N	354.1	mg/L	0.02	<0.02	<0.02	<0.02
SOLIDS, TOTAL DISSOLVED (TDS)	160.1	mg/L	13	5,160	7,960	6,240
CARBON, TOTAL ORGANIC (MAX)	9060	mg/L	1	10	7.6	9.0
CARBON, TOTAL ORGANIC (MIN)	9060	mg/L	1	9.4	7.0	5.7
CARBON, TOTAL ORGANIC (AVE)	9060	mg/L	1	9.6	7.3	7.0
Dilution Factor				400	500	400
CHLORIDE	300.0	mg/L	0.2	2,740	4,110	3,090
ORTHOPHOSPHATE AS P	300.0	mg/L	0.1	18.8J	<50	<40
SULFATE	300.0	mg/L	0.5	557	690	560
Dilution Factor				1	1	1
ARSENIC	6010B	µg/L	5	<5	<5	<5
IRON	6010B	µg/L	50	2,110	2,300	2,800
MANGANESE	6010B	µg/L	10	408	504	461
VANADIUM	6010B	µg/L	10	2.9J	2.7J	3.2J
Dilution Factor				5	1	1
PHC AS GASOLINE	M8015V	mg/L	0.05	4.0 (a)	0.19 (a)	1.75 (a)
VOLATILE ORGANICS						
Dilution Factor				50	10	50
CIS-1,2-DICHLOROETHENE	8260B	µg/L	0.5	8,670 (b)	272	3,140 (c)
TETRACHLOROETHENE (PCE)	8260B	µg/L	0.5	<25	<5	<25
TRICHLOROETHENE (TCE)	8260B	µg/L	0.5	<25	<5	<25
VINYL CHLORIDE	8260B	µg/L	0.5	1,520	174	935
Dilution Factor				5	5	5
METHANE	RSK175	µg/L	3	160	99	160
Dilution Factor				1	1	1
ETHANE	RSK175	µg/L	5	<5	<5	<5
ETHENE	RSK175	µg/L	3	31	28	44

Applied P & CH Laboratories

13760 Magnolia Ave., Chino, CA 91710

Tel: (909) 590-1828 Fax: (909) 590-1498

**APCL Analytical Report**

Component Analyzed	Method	Unit	PQL	Analysis Result	
				11GP27 05-02580-4	11GP24 DUP 05-02580-5
BROMIDE	320.1	mg/L	1	3.3	7.4
HARDNESS	130.2	mg/L	3	560	770
NITRATE AS N	353.3	mg/L	0.1	0.59	0.056J
NITRITE AS N	354.1	mg/L	0.02	0.011J	< 0.02
SOLIDS, TOTAL DISSOLVED (TDS)	160.1	mg/L	13	5,340	4,950
CARBON, TOTAL ORGANIC (MAX)	9060	mg/L	1	10.6	10.1
CARBON, TOTAL ORGANIC (MIN)	9060	mg/L	1	9.2	9.0
CARBON, TOTAL ORGANIC (AVE)	9060	mg/L	1	9.7	9.6
Dilution Factor				200	400
CHLORIDE	300.0	mg/L	0.2	1,240	2,480
ORTHOPHOSPHATE AS P	300.0	mg/L	0.1	< 20	< 40
SULFATE	300.0	mg/L	0.5	388	540
Dilution Factor				1	1
ARSENIC	6010B	µg/L	5	2.8J	< 5
IRON	6010B	µg/L	50	34.6J	2,130
MANGANESE	6010B	µg/L	10	461	417
VANADIUM	6010B	µg/L	10	3.9J	2.6J
Dilution Factor				1	5
PHC AS GASOLINE	M8015V	mg/L	0.05	2.69 (a)	3.7 (a)
VOLATILE ORGANICS					
Dilution Factor				25	50
CIS-1,2-DICHLOROETHENE	8260B	µg/L	0.5	4,510 (d)	8,900 (b)
TETRACHLOROETHENE (PCE)	8260B	µg/L	0.5	< 13	< 25
TRICHLOROETHENE (TCE)	8260B	µg/L	0.5	< 13	< 25
VINYL CHLORIDE	8260B	µg/L	0.5	2,700 (d)	1,670 (b)
Dilution Factor				5	5
METHANE	RSK175	µg/L	3	200	140
Dilution Factor				1	1
ETHANE	RSK175	µg/L	5	< 5	< 5
ETHENE	RSK175	µg/L	3	89	27

Component Analyzed	Method	Unit	PQL	Analysis Result	
				11MW07 05-02580-11	TRIP BLANK 05-02580-12
BROMIDE	320.1	mg/L	1	8.2	-
HARDNESS	130.2	mg/L	3	775	-
NITRATE AS N	353.3	mg/L	0.1	0.21	-
NITRITE AS N	354.1	mg/L	0.02	< 0.02	-
SOLIDS, TOTAL DISSOLVED (TDS)	160.1	mg/L	13	5,520	-
CARBON, TOTAL ORGANIC (MAX)	9060	mg/L	1	7.3	-
CARBON, TOTAL ORGANIC (MIN)	9060	mg/L	1	6.2	-

Applied P & CH Laboratories

13760 Magnolia Ave., Chino, CA 91710

Tel: (909) 590-1828 Fax: (909) 590-1498

**APCL Analytical Report**

Component Analyzed	Method	Unit	PQL	Analysis Result	
				11MW07 05-02580-11	TRIP BLANK 05-02580-12
<b>CARBON, TOTAL ORGANIC (AVE)</b>	9060	mg/L	1	6.8	-
Dilution Factor				400	1
<b>CHLORIDE</b>	300.0	mg/L	0.2	2,600	-
<b>ORTHOPHOSPHATE AS P</b>	300.0	mg/L	0.1	< 40	-
<b>SULFATE</b>	300.0	mg/L	0.5	590	-
Dilution Factor				1	1
<b>ARSENIC</b>	6010B	µg/L	5	< 5	-
<b>IRON</b>	6010B	µg/L	50	3,970	-
<b>MANGANESE</b>	6010B	µg/L	10	561	-
<b>VANADIUM</b>	6010B	µg/L	10	1.3J	-
Dilution Factor				1	1
<b>PHC AS GASOLINE</b>	M8015V	mg/L	0.05	1.51 (a)	-
<b>VOLATILE ORGANICS</b>					
Dilution Factor				1	1
<b>CIS-1,2-DICHLOROETHENE</b>	8260B	µg/L	0.5	1,000 (c)	< 0.5
<b>TETRACHLOROETHENE (PCE)</b>	8260B	µg/L	0.5	< 0.5	< 0.5
<b>TRICHLOROETHENE (TCE)</b>	8260B	µg/L	0.5	< 0.5	< 0.5
<b>VINYL CHLORIDE</b>	8260B	µg/L	0.5	613 (c)	< 0.5
Dilution Factor				5	1
<b>METHANE</b>	RSK175	µg/L	3	140	-
<b>ETHANE</b>	RSK175	µg/L	5	< 25	-
<b>ETHENE</b>	RSK175	µg/L	3	130	-

**II . Analysis of Soil Samples**

Component Analyzed	Method	Unit	PQL	Analysis Result	
				11GP24(10-20) 05-02580-6	11GP25(10-22) 05-02580-7
<b>MOISTURE</b>	ASTM-D2216	%Moisture	0.5	23.2	21.0
<b>CARBON, TOTAL ORGANIC (MAX)</b>	9060	mg/kg	100	550	4,970
<b>CARBON, TOTAL ORGANIC (MIN)</b>	9060	mg/kg	100	250	1,250
<b>CARBON, TOTAL ORGANIC (AVE)</b>	9060	mg/kg	100	400	2,970
Dilution Factor				1	1
<b>ARSENIC</b>	6010B	mg/kg	0.3	0.31	0.55
<b>IRON</b>	6010B	mg/kg	3	9,830	11,000
<b>MANGANESE</b>	6010B	mg/kg	3	100	117
<b>VANADIUM</b>	6010B	mg/kg	0.5	30.6	34.5

Applied P & CH Laboratories

13760 Magnolia Ave., Chino, CA 91710

Tel: (909) 590-1828 Fax: (909) 590-1498

# APCL Analytical Report

Component Analyzed	Method	Unit	PQL	Analysis Result		
				11GP26(10-22) 05-02580-8	11GP27(14-22) 05-02580-9	11GP27(14-22)DUP 05-02580-10
MOISTURE	ASTM-D2216	%Moisture	0.5	25.1	21.4	13.5
CARBON, TOTAL ORGANIC (MAX)	9060	mg/kg	100	1,300	930	390
CARBON, TOTAL ORGANIC (MIN)	9060	mg/kg	100	360	<100	200
CARBON, TOTAL ORGANIC (AVE)	9060	mg/kg	100	660	363	260
Dilution Factor				1	1	1
ARSENIC	6010B	mg/kg	0.3	0.46	0.48	0.45
IRON	6010B	mg/kg	3	6,230	4,300	6,090
MANGANESE	6010B	mg/kg	3	57.9	41.8	63.9
VANADIUM	6010B	mg/kg	0.5	20.8	13.2	18.6

PQL: Practical Quantitation Limit. MDL: Method Detection Limit. CRDL: Contract Required Detection Limit

N.D.: Not Detected or less than the practical quantitation limit.

“-”: Analysis is not required.

J: Reported between PQL and MDL.

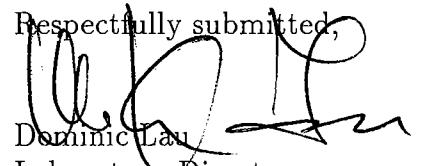
Listed Dilution Factors (DF) are relative to the method default DF. All unlisted DF's are 1.0

(a) Not a gasoline pattern, sample chromatogram only contained one peak which might be originated from VOC's.

(b) Analyzed with a dilution factor of 1000.

(c) Analyzed with a dilution factor of 100.

(d) Analyzed with a dilution factor of 250.

Respectfully submitted,  
  
Dominic Lau  
Laboratory Director  
Applied P & CH Laboratories



## Bioavailable Ferric Iron Assay Report

**Client:** ESTCP/NAVFACCO  
**Site:** SPAWAR  
**Sample Collection Date:** 5/3/2005  
**Analyst:** DAB/PJE  
**Analysis Date:** 6/14/2005

<b>Sample</b>	<b>Solids (%)</b>	<b>Ambient Fe II (mg/kg)</b>	<b>Bioavailable Fe III (mg/kg)</b>
11GP24	NA	553	1382
11GP24 dup	NA	553	910
11GP25	NA	1290	1694
11GP25 dup	NA	1281	908
11GP26	NA	369	1267
11GP26 dup	NA	369	1521
11GP27	NA	276	634
11GP27 dup	NA	267	597

**Table E1**  
**University of Massachusetts Electron Shuttling Capacity Data**

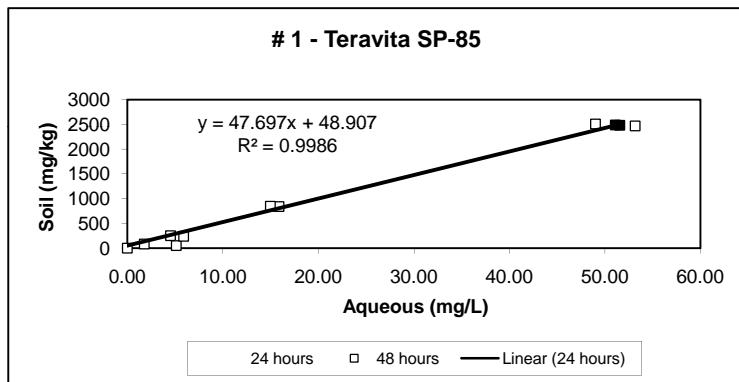
No.	Supplier	Product	Form	Test Conc.	Units	Shutting Capacity Fe Reduced (mM)			Shutting Capacity % of 0.5 g/L IHSS Soil Humic Acid standard	Shutting Capacity Fe Reduced (mM) for duplicates
						Avg	St. Dev	RPD		
1	TeraVita	SP-85	85% soluble solid	1.0	g/L	0.233	0.053	32%	79	0.27 0.195
2	Luscar Ltd	Dry Soluble 80	100% soluble solid	1.0	g/L	0.222	0.008	5%	76	0.216 0.228
3	Luscar Ltd	Liquid 12000	12% Liquid	8.3	mL/L	0.174	0.025	21%	59	0.156 0.192
4	Triad	Huma K	100% soluble solid	1.0	g/L	0.186	0.030	20%	63	0.192 0.234
5	Live Earth Products	12% Liquid Humic Acid	12% Liquid	8.3	mL/L	0.189	0.042	32%	76	0.219 0.159
6	Monterey AgResources	HA-12	12% Liquid	8.3	mL/L	0.243	0.008	5%	98	0.237 0.249
7	Humate International	Humate AS	100% soluble solid	1.0	g/L	0.141	0.008	9%	57	0.147 0.135
8	Humus Products of America	15% Concentrated Liquid Humus	15% Liquid	6.7	mL/L	0.158	0.023	21%	51	0.141 0.174
9	LignoTech	BorreGro HA-2	100% soluble solid	1.0	g/L	0.171	0.013	11%	55	0.162 0.18
10	LignoTech	BorreGro HA-1	100% soluble solid	1.0	g/L	0.084	0.055	93%	27	0.123 0.045
11	Horizon Ag Products	Quantum H	7% Liquid	14.3	mL/L	0.210	0.047	31%	68	0.177 0.243
12	UAS America	Super Hume	17% Liquid	5.9	mL/L	0.123	0.025	29%	36	0.105 0.141
13	Northwest Agricultural Products	Ful-Vac 3	3% Liquid	33.3	mL/L	0.054	0.000	0%	16	0.054 0.054
14	Natural Resources Group	F Power 10%	10% Liquid	10.0	mL/L	0.041	0.037	119%	12	0.018 0.071
15	Humatech	Aqua F	Liquid	33.3	mL/L	0.060	0.042	100%	17	0.03 0.09
16	Spectrum	Menadione sodium bisulfite	Solid	0.1	g/L	0.000	0.000	NA	0	0 0
17	Acros Fisher	Anthraquinone-2,6-disulfonic acid (AQDS)	Solid	0.1	g/L	0.220	0.060	39%	72	0.2621 0.1769
18	Spectrum	Anthraquinone-2-sulfonic acid (AQS)	Solid	1.0	g/L	0.121	0.064	77%	40	0.1648 0.0736
19	Spectrum	Indigo disulfonate	Solid	0.1	g/L	0.243	0.015	9%	80	0.2319 0.2532
20	Acros Fisher	Lawson	Solid	0.1	g/L	0.019	0.042	200%	8.3	0 0.06
21	Henna Global Wholesale	Henna	Solid	1.0	g/L	0.087	0.019	31%	38	0.073 0.1
22	IHSS	Soil Humic Acid Standard (control)	Solid	0.5	g/L	0.288	0.04	NA	100	

Shutting Capacity of control 0.5 g/L IHSS Soil Humic Acid Standard 0.288 +/- 0.040 mM Fe reduced.

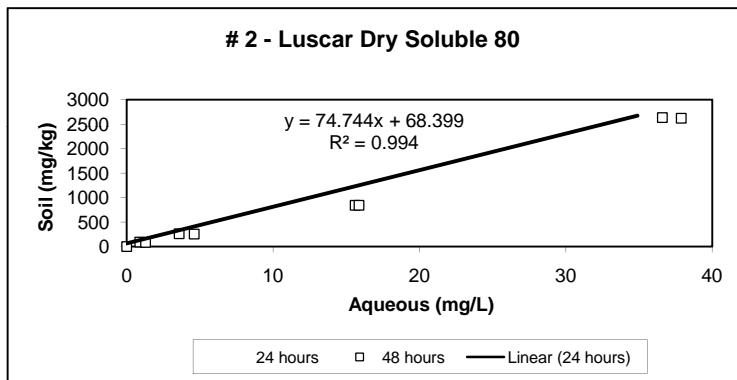
## **Appendix F**

## **Isotherm Data**

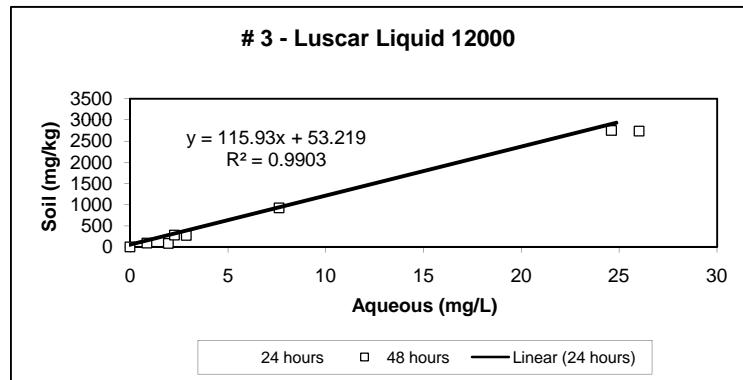
#1 Teravita SP-85	Sample Name	Initial Conc (mg/L)	Water (mL)	1 g/L shuttle (mL)	24 hour sample								48 hour sample							
					Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)	Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)				
						Diluted	Sample	Actual	Corrected			Diluted	Sample	Actual	Corrected					
1	0	1	0	10	1	0.028	0.028	4.30	0.00	0.000	1	0.031	0.031	4.76	0	0.000				
1	0	2	0	10	1	0.034	0.034	5.22	0.00	0.000	1	0.034	0.034	5.22	0	0.000				
1	10	1	10	9.9	1	0.034	0.034	5.22	0.46	95.398	1	0.066	0.066	10.12	5.1389376	48.611				
1	10	2	10	9.9	1	0.031	0.031	4.76	0.00	100.000	1	0.044	0.044	6.75	1.7641129	82.359				
1	30	1	30	9.7	1	0.062	0.062	9.51	4.76	252.446	1	0.071	0.071	10.89	5.9059432	240.941				
1	30	2	30	9.7	1	0.06	0.06	9.20	4.45	255.514	1	0.062	0.062	9.51	4.5253331	254.747				
1	100	1	100	9	1	0.133	0.133	20.40	15.65	843.531	1	0.136	0.136	20.86	15.877016	841.230				
1	100	2	100	9	1	0.136	0.136	20.86	16.11	838.929	1	0.13	0.13	19.94	14.956609	850.434				
1	300	1	300	7	1	0.364	0.364	55.84	51.08	2489.174	1	0.352	0.352	54.00	49.011658	2509.883				
1	300	2	300	7	1	0.367	0.367	56.30	51.54	2484.572	1	0.379	0.379	58.14	53.153489	2468.465				



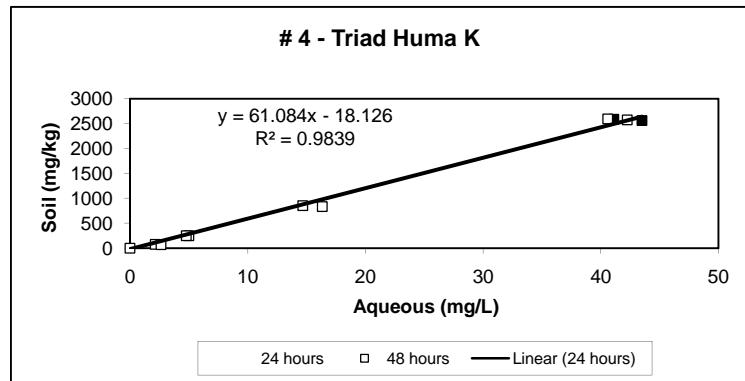
#2 Luscar Dry Soluble 80				24 hour sample						48 hour sample					
Sample Name	Initial Conc (mg/L)	Water (mL)	1 g/L shuttle (mL)	Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)	Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)
					Diluted	Sample	Actual	Corrected			Diluted	Sample	Actual	Corrected	
2 0 1	0	10	0	1	0.041	0.041	5.249488	0	0.000	1	0.032	0.032	4.0972	0	0.000
2 0 2	0	10	0	1	0.034	0.034	4.353234	0	0.000	1	0.038	0.038	4.8654	0	0.000
2 10 1	10	9.9	0.1	1	0.041	0.041	5.249488	0.448127	95.519	1	0.042	0.042	5.3775	0.896254	91.037
2 10 2	10	9.9	0.1	1	0.041	0.041	5.249488	0.448127	95.519	1	0.045	0.045	5.7616	1.2803629	87.196
2 30 1	30	9.7	0.3	1	0.059	0.059	7.554141	2.7527802	272.472	1	0.063	0.063	8.0663	3.5850161	264.150
2 30 2	30	9.7	0.3	1	0.040	0.04	5.121452	0.3200907	296.799	1	0.071	0.071	9.0906	4.6093064	253.907
2 100 1	100	9	1	1	0.128	0.128	16.38865	11.587284	884.127	1	0.157	0.157	20.102	15.620427	843.796
2 100 2	100	9	1	1	0.126	0.126	16.13257	11.331212	886.688	1	0.159	0.159	20.358	15.8765	841.235
2 300 1	300	7	3	1	0.303	0.303	38.795	33.993635	2660.064	1	0.321	0.321	41.1	36.618379	2633.816
2 300 2	300	7	3	1	0.310	0.31	39.69125	34.889889	2651.101	1	0.331	0.331	42.38	37.898742	2621.013



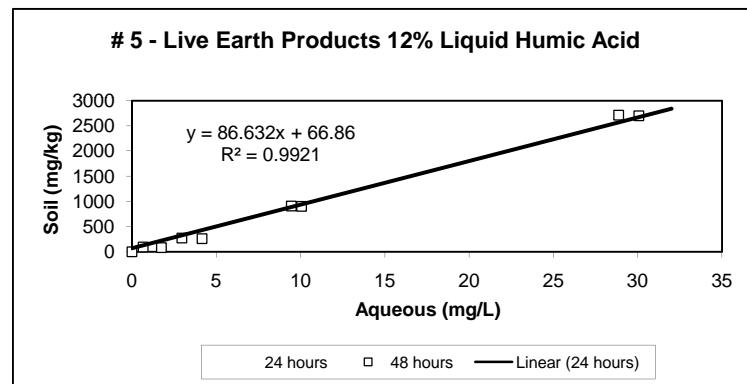
#3 Luscar Liquid 12000	24 hour sample										48 hour sample									
	Sample Name	Initial Conc (mg/L)	Water (mL)	1 g/L shuttle (mL)	Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)	Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)				
						Diluted	Sample	Actual	Corrected			Diluted	Sample	Actual	Corrected					
3 0 1	0	10	0	1	0.029	0.029	2.929124	0	0.000	1	0.032	0.032	3.2321	0	0.000					
3 0 2	0	10	0	1	0.037	0.037	3.737158	0	0.000	1	0.035	0.035	3.5351	0	0.000					
3 10 1	10	9.9	0.1	1	0.029	0.029	2.929124	-0.404017	104.040	1	0.042	0.042	4.2422	0.8585363	91.415					
3 10 2	10	9.9	0.1	1	0.037	0.037	3.737158	0.4040171	95.960	1	0.053	0.053	5.3532	1.9695833	80.304					
3 30 1	30	9.7	0.3	1	0.059	0.059	5.959252	2.626111	273.739	1	0.056	0.056	5.6562	2.2725961	277.274					
3 30 2	30	9.7	0.3	1	0.051	0.051	5.151218	1.8180769	281.819	1	0.062	0.062	6.2623	2.8786217	271.214					
3 100 1	100	9	1	1	0.101	0.101	10.20143	6.8682904	931.317	1	0.109	0.109	11.009	7.6258225	923.742					
3 100 2	100	9	1	1	0.109	0.109	11.00947	7.6763246	923.237	1	0.109	0.109	11.009	7.6258225	923.742					
3 300 1	300	7	3	1	0.279	0.279	28.18019	24.847051	2751.529	1	0.277	0.277	27.978	24.59454	2754.055					
3 300 2	300	7	3	1	0.249	0.249	25.15006	21.816923	2781.831	1	0.291	0.291	29.392	26.0086	2739.914					



#4 Triad Huma K	Sample Name	Initial Conc (mg/L)	Water (mL)	1 g/L shuttle (mL)	24 hour sample								48 hour sample							
					Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)	Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)				
						Diluted	Sample	Actual	Corrected			Diluted	Sample	Actual	Corrected					
4 0 1		0	10	0	1	0.044	0.044	5.25	0	0.000	1	0.055	0.055	6.56	0	0.000				
4 0 2		0	10	0	1	0.041	0.041	4.89	0	0.000	1	0.057	0.057	6.80	0	0.000				
4 10 1		10	9.9	0.1	1	0.054	0.054	6.44	1.3720344	86.280	1	0.074	0.074	8.83	2.147532	78.525				
4 10 2		10	9.9	0.1	1	0.049	0.049	5.85	0.7754977	92.245	1	0.078	0.078	9.31	2.6247614	73.752				
4 30 1		30	9.7	0.3	1	0.079	0.079	9.43	4.3547178	256.453	1	0.098	0.098	11.69	5.0109081	249.891				
4 30 2		30	9.7	0.3	1	0.117	0.117	13.96	8.8883965	211.116	1	0.096	0.096	11.45	4.7722934	252.277				
4 100 1		100	9	1	1	0.142	0.142	16.94	11.87108	881.289	1	0.193	0.193	23.03	16.345105	836.549				
4 100 2		100	9	1	1	0.164	0.164	19.57	14.495841	855.042	1	0.179	0.179	21.36	14.674802	853.252				
4 300 1		300	7	3	1	0.387	0.387	46.17	41.101377	2588.986	1	0.396	0.396	47.25	40.564494	2594.355				
4 300 2		300	7	3	1	0.407	0.407	48.56	43.487524	2565.125	1	0.41	0.41	48.92	42.234797	2577.652				



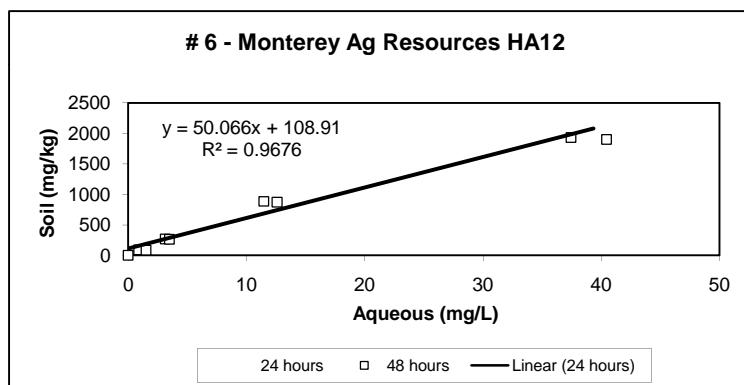
#5 Live Earth Products 12% Liquid Humic Acid				24 hour sample						48 hour sample					
Sample Name	Initial Conc (mg/L)	Water (mL)	1 g/L shuttle (mL)	Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)	Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)
					Diluted	Sample	Actual	Corrected			Diluted	Sample	Actual	Corrected	
5 0 1	0	10	0	1	0.032	0.032	3.86	0	0.000	1	0.052	0.052	6.27	0	0.000
5 0 2	0	10	0	1	0.025	0.025	3.01	0	0.000	1	0.049	0.049	5.91	0	0.000
5 10 1	10	9.9	0.1	1	0.033	0.033	3.98	0.5425048	94.575	1	0.056	0.056	6.75	0.6630614	93.369
5 10 2	10	9.9	0.1	1	0.033	0.033	3.98	0.5425048	94.575	1	0.065	0.065	7.84	1.7480711	82.519
5 30 1	30	9.7	0.3	1	0.046	0.046	5.55	2.109741	278.903	1	0.075	0.075	9.04	2.9536374	270.464
5 30 2	30	9.7	0.3	1	0.047	0.047	5.67	2.2302976	277.697	1	0.085	0.085	10.25	4.1592036	258.408
5 100 1	100	9	1	1	0.095	0.095	11.45	8.0170157	919.830	1	0.129	0.129	15.55	9.4636952	905.363
5 100 2	100	9	1	1	0.109	0.109	13.14	9.7048085	902.952	1	0.134	0.134	16.15	10.066478	899.335
5 300 1	300	7	3	1	0.269	0.269	32.43	28.993869	2710.061	1	0.3	0.3	36.17	30.078878	2699.211
5 300 2	300	7	3	1	0.294	0.294	35.44	32.007785	2679.922	1	0.29	0.29	34.96	28.873312	2711.267



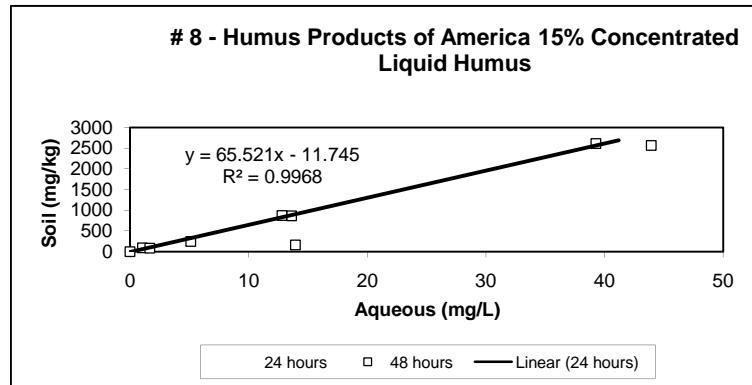
#6 Monterey Ag Resources HA12	Sample Name	Initial Conc (mg/L)	Water (mL)	1 g/L shuttle (mL)	24 hour sample						48 hour sample					
					Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)	Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)
						Diluted	Sample	Actual	Corrected			Diluted	Sample	Actual	Corrected	
6 0 1		0	10	0	1	0.036	0.036	3.10	0	0.000	1	0.032	0.032	2.75	0	0.000
6 0 2		0	10	0	1	0.033	0.033	2.84	0	0.000	1	0.037	0.037	3.18	0	0.000
6 10 1	10	9.9	0.1		1	0.042	0.042	3.61	0.6448364	93.552	1	0.045	0.045	3.87	0.902771	90.972
6 10 2	10	9.9	0.1		1	0.05	0.05	4.30	1.3326619	86.673	1	0.052	0.052	4.47	1.5046183	84.954
6 30 1	30	9.7	0.3		1	0.07	0.07	6.02	3.0522256	269.478	1	0.071	0.071	6.10	3.1382038	268.618
6 30 2	30	9.7	0.3		1	0.067	0.067	5.76	2.794291	272.057	1	0.075	0.075	6.45	3.4821165	265.179
6 100 1	100	9	1		1	0.176	0.176	15.13	12.165913	878.341	1	0.181	0.181	15.56	12.595804	874.042
6 100 2	100	9	1		1	0.153	0.153	13.15	10.188415	898.116	1	0.168	0.168	14.44	11.478088	885.219
6 300 1	231	10	3		1	0.451	0.451	38.78	35.809915	1949.593	1	0.47	0.47	40.41	37.4435	1933.257
6 300 2	231	10	3		1	0.492	0.492	42.30	39.33502	1914.342	1	0.505	0.505	43.42	40.452737	1903.165

Note:

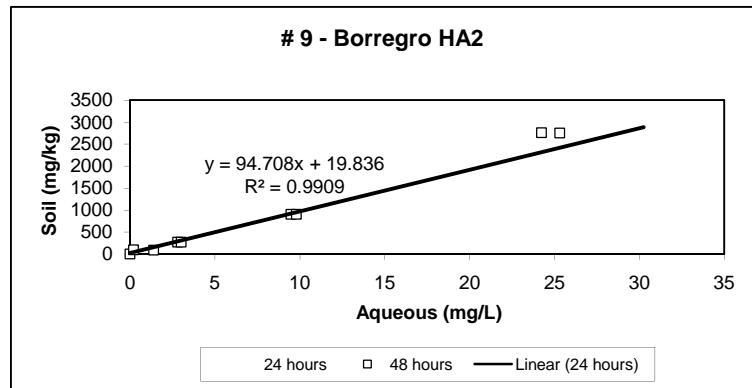
6-300-1, 6-300-2 had 10 ml of GW added instead of 7ml



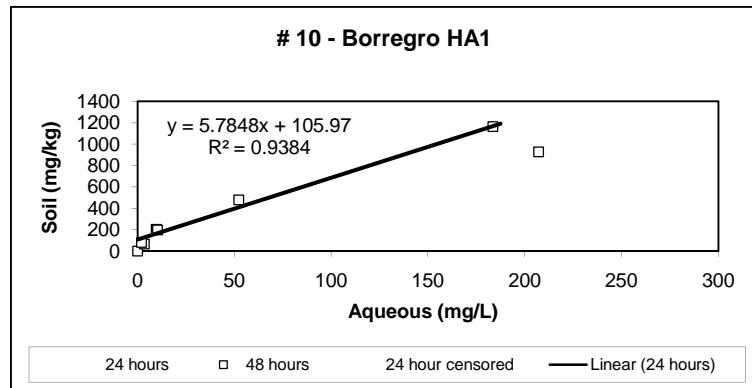
#8 Humus Products of America 15% Concentrated Liquid Humus				24 hour sample						48 hour sample					
Sample Name	Initial Conc (mg/L)	Water (mL)	1 g/L shuttle (mL)	Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)	Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)
					Diluted	Sample	Actual	Corrected			Diluted	Sample	Actual	Corrected	
8 0 1	0	10	0	1	0.036	0.036	3.64879	0	0.000	1	0.076	0.076	7.703	0	0.000
8 0 2	0	10	0	1	0.041	0.041	4.155566	0	0.000	1	0.067	0.067	6.7908	0	0.000
8 10 1	10	9.9	0.1	1	0.057	0.057	5.77725	1.8750724	81.249	1	0.082	0.082	8.3111	1.0642303	89.358
8 10 2	10	9.9	0.1	1	0.059	0.059	5.979961	2.0777829	79.222	1	0.088	0.088	8.9193	1.6723619	83.276
8 30 1	30	9.7	0.3	1	0.075	0.075	7.601645	3.6994672	263.005	1	0.122	0.122	12.365	5.1184409	248.816
8 30 2	30	9.7	0.3	1	0.081	0.081	8.209776	4.3075987	256.924	1	0.209	0.209	21.183	13.936349	160.637
8 100 1	100	9	1	1	0.162	0.162	16.41955	12.517375	874.826	1	0.206	0.206	20.879	13.632283	863.677
8 100 2	100	9	1	1	0.175	0.175	17.73717	13.834994	861.650	1	0.198	0.198	20.068	12.821441	871.786
8 300 1	300	7	3	1	0.419	0.419	42.46786	38.565678	2614.343	1	0.459	0.459	46.522	39.275165	2607.248
8 300 2	300	7	3	1	0.445	0.445	45.10309	41.200915	2587.991	1	0.505	0.505	51.184	43.937507	2560.625



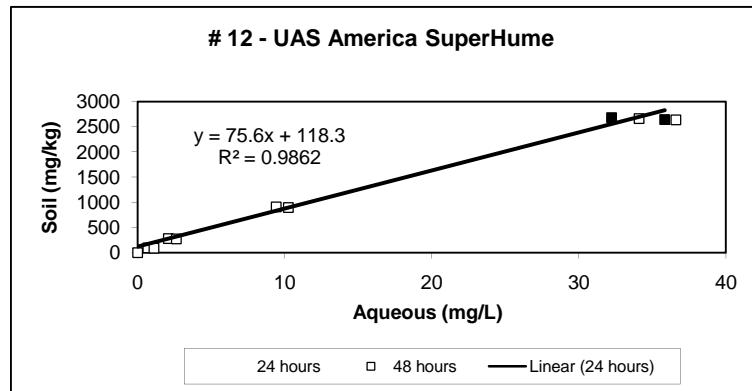
#9 Borregro HA2	Sample Name	Initial Conc (mg/L)	Water (mL)	1 g/L shuttle (mL)	24 hour sample								48 hour sample							
					Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)	Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)				
						Diluted	Sample	Actual	Corrected			Diluted	Sample	Actual	Corrected					
9 0 1		0	10	0	1	0.041	0.041	4.41	0	0.000	1	0.062	0.062	6.68	0	0.000				
9 0 2		0	10	0	1	0.037	0.037	3.98	0	0.000	1	0.048	0.048	5.17	0	0.000				
9 10 1		10	9.9	0.1	1	0.046	0.046	4.95	0.7536606	92.463	1	0.068	0.068	7.32	1.3996555	86.003				
9 10 2		10	9.9	0.1	1	0.052	0.052	5.60	1.3996555	86.003	1	0.057	0.057	6.14	0.2153316	97.847				
9 30 1		30	9.7	0.3	1	0.058	0.058	6.24	2.0456503	279.543	1	0.081	0.081	8.72	2.7993109	272.007				
9 30 2		30	9.7	0.3	1	0.067	0.067	7.21	3.0146425	269.854	1	0.083	0.083	8.94	3.0146425	269.854				
9 100 1		100	9	1	1	0.118	0.118	12.70	8.5055986	914.944	1	0.143	0.143	15.40	9.4745909	905.254				
9 100 2		100	9	1	1	0.128	0.128	13.78	9.5822567	904.177	1	0.146	0.146	15.72	9.7975883	902.024				
9 300 1		300	7	3	1	0.32	0.32	34.45	30.254091	2697.459	1	0.29	0.29	31.22	25.301464	2746.985				
9 300 2		300	7	3	1	0.286	0.286	30.79	26.593454	2734.065	1	0.28	0.28	30.15	24.224806	2757.752				



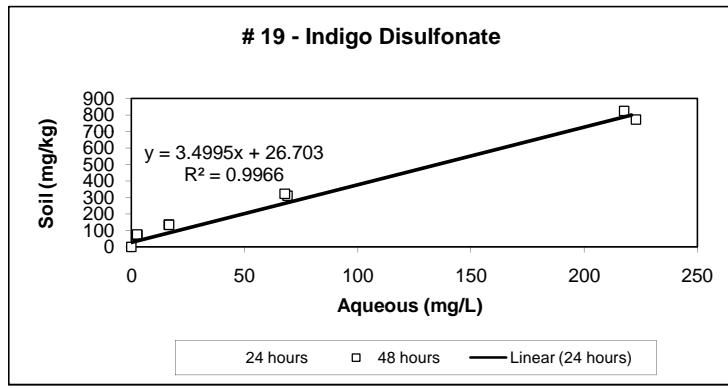
#10 Borrego HA1	Sample Name	Initial Conc (mg/L)	Water (mL)	1 g/L shuttle (mL)	24 hour sample								48 hour sample							
					Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)	Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)				
						Diluted	Sample	Actual	Corrected			Diluted	Sample	Actual	Corrected					
10 0 1		0	10	0	1	0.042	0.042	6.19	0	0.000	1	0.045	0.045	6.63	0	0.000				
10 0 2		0	10	0	1	0.047	0.047	6.93	0	0.000	1	0.049	0.049	7.22	0	0.000				
10 10 1	10	9.9	0.1		1	0.062	0.062	9.14	2.5800337	74.200	1	0.071	0.071	10.47	3.5383319	64.617				
10 10 2	10	9.9	0.1		1	0.058	0.058	8.55	1.9903117	80.097	1	0.061	0.061	8.99	2.064027	79.360				
10 30 1	30	9.7	0.3		1	0.102	0.102	15.04	8.4772536	215.227	1	0.112	0.112	16.51	9.5829823	204.170				
10 30 2	30	9.7	0.3		1	0.097	0.097	14.30	7.7401011	222.599	1	0.116	0.116	17.10	10.172704	198.273				
10 100 1	100	9	1		1	0.379	0.379	55.88	49.315501	506.845	1	0.401	0.401	59.12	52.190396	478.096				
10 100 2	100	9	1		1	0.38	0.38	56.02	49.462932	505.371	1	0.401	0.401	59.12	52.190396	478.096				
10 300 1	300	7	3		4	0.329	1.316	194.02	187.45788	1125.421	4	0.323	1.292	190.48	183.55097	1164.490				
10 300 2	300	7	3		4	0.434	1.736	255.94	249.37869	506.213	4	0.363	1.452	214.07	207.13985	928.602				



#12 UAS America SuperHume	Sample Name	Initial Conc (mg/L)	Water (mL)	1 g/L shuttle (mL)	24 hour sample								48 hour sample							
					Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)	Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)				
						Diluted	Sample	Actual	Corrected			Diluted	Sample	Actual	Corrected					
12 0 1		0	10	0	1	0.032	0.032	4.44	0	0.000	1	0.035	0.035	4.85	0	0.000				
12 0 2		0	10	0	1	0.037	0.037	5.13	0	0.000	1	0.043	0.043	5.96	0	0.000				
12 10 1		10	9.9	0.1	1	0.035	0.035	4.85	0.0693014	99.307	1	0.044	0.044	6.10	0.6930144	93.070				
12 10 2		10	9.9	0.1	1	0.035	0.035	4.85	0.0693014	99.307	1	0.047	0.047	6.51	1.1088231	88.912				
12 30 1		30	9.7	0.3	1	0.045	0.045	6.24	1.4553303	285.447	1	0.054	0.054	7.48	2.0790432	279.210				
12 30 2		30	9.7	0.3	1	0.052	0.052	7.21	2.4255505	275.744	1	0.058	0.058	8.04	2.6334548	273.665				
12 100 1		100	9	1	1	0.098	0.098	13.58	8.8012831	911.987	1	0.113	0.113	15.66	10.256613	897.434				
12 100 2		100	9	1	1	0.093	0.093	12.89	8.1082687	918.917	1	0.107	0.107	14.83	9.424996	905.750				
12 300 1		300	7	3	1	0.267	0.267	37.01	32.22517	2677.748	1	0.285	0.285	39.50	34.096309	2659.037				
12 300 2		300	7	3	1	0.293	0.293	40.61	35.828845	2641.712	1	0.303	0.303	42.00	36.591161	2634.088				



#19 Indigo Carmine	Sample Name	24 hour sample						48 hour sample									
		Initial Conc (mg/L)	Water (mL)	1 g/L shuttle (mL)	Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)		Dilution	Abs (350 nm)		Aq Conc (mg/L)		Calc Soil Conc. (mg/kg)
						Diluted	Sample	Actual	Corrected	0.000	1		0.06	0.06	8.78	0	0.000
19	0	1	0	10	0	1	0.029	0.029	4.24	0	0.000	1	0.06	0.06	8.78	0	0.000
19	0	2	0	10	0	1	0.032	0.032	4.68	0	0.000	1	0.062	0.062	9.07	0	0.000
19	10	1	10	9.9	0.1	1	0.067	0.067	9.80	5.33937975	46.606	1	0.079	0.079	11.56	2.6331188	73.669
19	10	2	10	9.9	0.1	1	0.065	0.065	9.51	5.046811	49.532	1	0.078	0.078	11.41	2.4868344	75.132
19	30	1	30	9.7	0.3	1	0.152	0.152	22.24	17.7735518	122.264	1	0.174	0.174	25.45	16.530135	134.699
19	30	2	30	9.7	0.3	1	0.164	0.164	23.99	19.5289643	104.710	1	0.175	0.175	25.60	16.676419	133.236
19	100	1	100	9	1	1	0.517	0.517	75.63	71.1673493	288.327	1	0.532	0.532	77.82	68.899941	311.001
19	100	2	100	9	1	1	0.524	0.524	76.65	72.19134	278.087	1	0.524	0.524	76.65	67.729666	322.703
19	300	1	300	7	3	4	0.385	1.54	225.28	220.816267	791.837	4	0.396	1.584	231.71	222.79111	772.089
19	300	2	300	7	3	4	0.384	1.536	224.69	220.231129	797.689	4	0.387	1.548	226.45	217.52487	824.751



A350

Concentration (mg/L)	0	12.5	25	50	100	slope
0	0.091		0.18	0.355	0.685	0.00684

